FISCAL YEAR 1992 DEPARTMENT OF ENERGY AUTHORIZATION

(Advanced Reactors and Facilities)

HEARING

BEFORE THE

SUBCOMMITTEE ON ENERGY

OF THE

COMMITTEE ON
SCIENCE, SPACE, AND TECHNOLOGY
HOUSE OF REPRESENTATIVES

ONE HUNDRED SECOND CONGRESS

FIRST SESSION

MARCH 6, 1991

[No. 4]

VOLUME II

Printed for the use of the
Committee on Science, Space, and Technology

U.S. GOVERNMENT PRINTING OFFICE
42-337 WASHINGTON : 1991

H701-41

For sale by the Superintendent of Documents, Congressional Sales Office
U.S. Government Printing Office, Washington, DC 20402

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

GEORGE E. BROWN, Jr., California, *Chairman*

JAMES H. SCHEUER, New York
MARILYN LLOYD, Tennessee
DAN GLICKMAN, Kansas
HAROLD L. VOLKMER, Missouri
HOWARD WOLPE, Michigan
RALPH M. HALL, Texas
DAVE McCURDY, Oklahoma
NORMAN Y. MINETA, California
TIM VALENTINE, North Carolina
ROBERT G. TORRICELLI, New Jersey
RICK BOUCHER, Virginia
TERRY L. BRUCE, Illinois
RICHARD H. STALLINGS, Idaho
JAMES A. TRAFICANT, Jr., Ohio
HENRY J. NOWAK, New York
CARL C. PERKINS, Kentucky
TOM McMILLEN, Maryland
DAVID R. NAGLE, Iowa
JIMMY HAYES, Louisiana
JERRY F. COSTELLO, Illinois
JOHN TANNER, Tennessee
GLEN BROWDER, Alabama
PETE GEREN, Texas
RAY THORNTON, Arkansas
JIM BACCHUS, Florida
TIM ROEMER, Indiana
BUD CRAMER, Alabama
DICK SWETT, New Hampshire
MICHAEL J. KOPETSKI, Oregon
JOAN KELLY HORN, Missouri
BARBARA-ROSE COLLINS, Michigan

ROBERT S. WALKER, Pennsylvania*
F. JAMES SENSENBRENNER, Jr., Wisconsin
SHERWOOD L. BOEHLERT, New York
TOM LEWIS, Florida
DON RITTER, Pennsylvania
SID MORRISON, Washington
RON PACKARD, California
PAUL B. HENRY, Michigan
HARRIS W. FAWELL, Illinois
D. FRENCH SLAUGHTER, Jr., Virginia
LAMAR SMITH, Texas
CONSTANCE A. MORELLA, Maryland
DANA ROHRABACHER, California
STEVEN H. SCHIFF, New Mexico
TOM CAMPBELL, California
JOHN J. RHODES III, Arizona
JOE BARTON, Texas
DICK ZIMMER, New Jersey
WAYNE T. GILCHREST, Maryland

Radford H. Byerly, *Chief of Staff*
Michael Rodemeyer, *Chief Counsel*
Carolyn C. Greenfeld, *Chief Clerk*
David D. Clement, *Republican Chief of Staff*

Subcommittee on Energy

MARILYN LLOYD, Tennessee, *Chairman*

JERRY F. COSTELLO, Illinois
RALPH M. HALL, Texas
TERRY L. BRUCE, Illinois
RICHARD H. STALLINGS, Idaho
JAMES A. TRAFICANT, Jr., Ohio
BUD CRAMER, Alabama
HOWARD WOLPE, Michigan
TIM ROEMER, Indiana

SID MORRISON, Washington
HARRIS W. FAWELL, Illinois
LAMAR SMITH, Texas
STEVEN H. SCHIFF, New Mexico
JOE BARTON, Texas

---

*Ranking Republican Member.

CONTENTS

WITNESSES

March 6, 1991: Page
Hon. William H. Young, Assistant Secretary for Nuclear Energy U.S. Department of Energy, Washington, DC 3
Arnold D. Aldrich, Associate Administrator, National Aeronautics and Space Administration, Washington, DC 41

Panel 1: Light Water Reactors

Dr. Shelby T. Brewer, president, Nuclear Business, Combustion Engineering, Windsor, CT 61
Nathanial D. Woodson, vice president, Energy Systems, Westinghouse Hanford Co., Pittsburgh, PA 67
Dr. Bertram Wolfe, vice president, General Electric, San Jose, CA 85
R. Patrick McDonald, executive vice president, Southern Nuclear Operating Co., Birmingham, AL 103

Panel 2: Helium [MHTGR] and Sodium Cooled Reactors/IFR

Dr. Charles E. Till, associate director, Argonne National Laboratory Argonne, IL 149
Linden S. Blue, vice chairman of the board, GA Technologies, Inc., Washington, DC 155
Dr. Alexander Zucker, associate director, Nuclear Technology Oak Ridge National Laboratory, Oak Ridge, TN 165

Panel 3: Facilities

Jeff Breckel, Special Assistant to the Governor, State of Washington, Olympia, WA 178
Roger C. Nichols, manager, government operations, Westinghouse Hanford Co., Richland, WA 184

APPENDIX I: Additional Material for the Record

Information provided by the Hon. William H. Young, Department of Energy, Washington, DC 256

APPENDIX II: Questions and Answers for the Record

Hon. William H. Young, Department of Energy, Washington, DC 261
Linden S. Blue, GA Technologies, Inc., Washington, DC 280
Dr. Charles E. Till, Argonne National Laboratory, Argonne, IL 283

1992 DEPARTMENT OF ENERGY AUTHORIZATION

WEDNESDAY, MARCH 6, 1991

U.S. HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY,
SUBCOMMITTEE ON ENERGY,
Washington, DC.

The Subcommittee met, pursuant to notice, at 9:10 a.m., in room 2318, Rayburn House Office Building, Hon. Marilyn Lloyd (Chairman of the Subcommittee) presiding.

Mrs. LLOYD. Good morning, ladies and gentlemen. I apologize for the delay. I am very pleased that we have this very important hearing today on the Department of Energy's budget request for fiscal year 1992 for the Nuclear Energy Program. We are now at a time in our history when there truly is a window of opportunity to move forward decisively, on the domestic energy front. However, we will not pass through this window if we proceed with a business-as-usual attitude.

The National Energy Strategy calls for an expanded role for nuclear power to meet our future energy needs. While this call is a necessary step in reestablishing nuclear energy in the United States, I assure you that by itself, it is not efficient. Both Government and industry must do their respective jobs and they must do them well. We must convince the American public that nuclear power is safe and economic, and that we are able to deal with the waste problem. Technology can certainly play a role in addressing these issues.

In our 1992 budget request, there is a significant increase in funding for the Nuclear Energy Program. On the surface, it appears that this would support the goals of the National Energy Strategy. However, closer inspection reveals that the lion's share of the increase is for space nuclear power applications, and not for our advanced reactors for our civilian power. So, we will want to look very closely at this at today's hearing. Along this line, we are pleased that Mr. Aldrich is with us. Mr. Aldrich is from NASA. He's on our witness list.

Finally, I want to remind our witnesses that today's hearing is intended to provide a base of information for our subcommittee to prepare a multi-year authorization. We are going to complete our authorizations this month so that we can take our bill to full committee after the Easter recess. To accomplish this, we are going to have to look well beyond fiscal year 1992. Our focus will be on the underlying strategy for our nuclear energy programs, the goals, and then, of course, the milestones, and the key decision points over the next several years. In short, we want to know how today's programs fit our long term strategy.

I do welcome all of our witnesses today, and we look forward to a very stimulating discussion. Of course, one of the things that I look forward to is to recognizing our distinguished Ranking Republican Member, the Honorable Sid Morrison, for his opening remarks. As all of you in this room know, Sid and I have worked together on energy issues for many years. His diligence and his insight into energy programs has certainly been invaluable to everyone in the nuclear arena. I look forward to our continuing relationship this year, Sid. We recognize you.

Mr. **Morrison**. Thank you, Madam Chairman. Thank you very much for the kind words. I do have a formal statement I will submit for the record. I am particularly excited about this morning's hearing, because it focuses on areas that are of particular interest to the two of us, Madam Chairman. But, we've watched this very carefully and we'd like to believe that with the efforts of many people in the audience and some support through the Department of Energy and enthusiastic support by this subcommittee that the nuclear option is alive and well. Let's hope that the orders begin to flow sometime in the mid-1990's with the next step. We will hear about that this morning as we talk about improved light water reactors, and also looking a little further into advanced reactors, and also with our guests interested in space development of power systems for space missions.

I'm also pleased that the third panel today, Madam Chairman, is a good example, I think, of international cooperation. We're hearing more and more about this these days. All of us around the world look at our energy future. We're pleased that the Governor of the State of Washington has a marketing team that is just back from attempting to work with the Japanese on future funding for the Fast Flux Test Facility, which is in some jeopardy as far as continued financing through the DOE, and more through the problems at OMB, I might add. So, I look forward to their report to us as we look at this total picture dealing with America's energy future.

Mrs. **Lloyd**. Thank you, Mr. Morrison. Without objection, your entire statement will be made a part of the record.

Are there members that have opening statements? Mr. Fawell?

Mr. **Fawell**. Thank you, Madam Chairman.

Our discussion today of advanced reactors and facilities in the Department of Energy's fiscal year 1992 budget takes on, of course, added importance in view of our involvement in the Persian Gulf. Hopefully, we have learned some very salient lessons over again, I would gather.

As we attempt to reduce our dependence on imported oil, it's imperative that we find cost-efficient, inherently safe, and environmentally sound sources of electricity generation options. Advanced nuclear technology will play a major role in meeting our energy needs of the future. I am pleased with the President's National Energy Strategy that has highlighted the safety and environmental features of the advanced liquid metal reactor program. The unique fuel cycle of the fast reactor holds, I believe, great promise in significantly reducing problems of waste disposal through its revolutionary fuel cycle. I look forward to the discussion of the benefits of this technology this morning.

I would also like to take this opportunity to welcome back to the committee Dr. Charles Till of Argonne National Laboratories. Dr. Till directs all of the engineering research divisions at Argonne and has led the direction of the integral fast reactor from its conception to its present status as the centerpiece of the Department of Energy's advanced reactor efforts. I look forward to the insight we will provide and to the progress and success of the IFE program, as well as the comments, of course, of Mr. Young. I must confess, as I have shared with the Chairlady, we happen to have a Labor Committee that seemingly always has the same dates of hearings as does this committee. I'm going to be a bit of a yo-yo today, coming back and forth. So, Madam Chairman, I may have to leave in a short period of time. I do hope I can be back in time, at least by the time of the second panel. I hope I can catch most of your comments, Dr. Young, also. Thank you, Madam Chairman.

Mrs. LLOYD. I share the frustration of the gentleman from Illinois. I just left an Armed Services Hearing. This is certainly something that happens this time of year to all of us.

It's good to see Dr. Alex Zucker from my district from Oak Ridge National Laboratory. We look forward to hearing from you, Alex, a little bit later on. I would like unanimous consent that these proceedings be allowed to be covered by the news media, electronic media—without objection, so ordered.

Our first witness today is the Honorable William Young, the Assistant Secretary for Nuclear Energy. He's a hard worker. We look forward to your testimony. At the conclusion of your testimony, we are going to hear from Mr. Aldrich from NASA. Please proceed, Bill.

STATEMENT OF HON. WILLIAM H. YOUNG, ASSISTANT SECRETARY FOR NUCLEAR ENERGY, DEPARTMENT OF ENERGY

Mr. YOUNG. Thank you, Madam Chairman. I am pleased to have this opportunity to present DOE's Fiscal Year 1992 budget and programs. It's a pleasure to appear before a Committee and a Chairman who have provided such leadership to the Nuclear Energy Program in the United States. I'll give a very brief summary of my testimony, so we'll have maximum time for questions.

The National Energy Strategy, developed by the Secretary of Energy at the President's direction, provides focus to DOE's future policy and funding initiatives. The NES identifies an important and growing role for nuclear energy as part of a balanced array of energy sources for meeting the Nation's energy needs, especially the growing demand for electricity. The NES also lays out a specific plan for overcoming the obstacles to nuclear power, for which the Fiscal Year 1992 budget is an initial increment of that.

The DOE has proposed legislation, associated with the NES, which would contribute to the expansion of nuclear power by reforming the current licensing process and helping in successful implementation of the Nuclear Waste Policy Act. We look forward to enactment of the provisions of that legislation by the Congress.

Let me highlight, briefly, several areas of special importance in our Fiscal Year 1992 budget.

During Fiscal Year 1992, DOE and industry will continue with two cooperative cost-shared programs to develop and certify advanced light water reactor designs. One program supports certification of two evolutionary standardized designs, while the second supports two advanced passive standardized designs. The objective of the NES is to have all four designs certified by 1985.

To provide a basis for commercial standardization, we are embarking on a program supporting first-of-a-kind engineering, to develop plant designs beyond those needed for NRC safety certification. A key element of the program will be industry or market interest as evidenced by proposed levels of cost-sharing. Our goal is to commercially standardize the design of at least one ALWR by 1995. We are pleased to see that industry interest in support of this program seems to be developing. It's in the ALWR area that we have provided the most significant increase in our budget to advance the prospects for an early order for nuclear power, with the objective of having a plant operational by the year 2000.

In the advanced reactors area, we will continue development of the advanced liquid metal reactor, its reactor, and its related integral fast reactor metal fuel cycle. We will also continue studies of the potential use of actinide recycling, using LWR fuel to contribute to the Nation's nuclear waste solution.

In fiscal 1992, we will continue to focus on Modular High Temperature Gas-Cooled Reactor design and licensing bases, and will concentrate on fuel and heat removal development. We have carefully integrated civilian with New Production Reactor MHTGR design and development to achieve maximum cost effectiveness by common activities. In this area of advanced reactors, we have proposed a slight decrease from the levels appropriated for Fiscal Year 1991. This is to make the most cost effective use of funds in very limited budget times, and is consistent with the status of the development of the technologies involved.

In cooperation with the user agencies, we will continue preparation of nuclear heat sources for the NASA CRAF and Cassini missions, and development of the SP-100 on a modified plan schedule. We are also proposing technology studies and new activities in support of the President's Space Exploration Initiative and NASA.

Let me add that the spending on the space activities reflects, in the area of the heat sources, a slight decrease. Consistent with the status of the program, it reflects for the SP-100 our full support of an administration—a multi-agency Memorandum of Agreement, which commits us to support of the development of the SP-100, which we strongly endorse. Our proposal does reflect the President's desire to move forward on the Space Exploration Initiative. It has been my pleasure in these activities to work closely with Arnie Aldrich, who is here with me. I think we have a very close working relationship in NASA, which is very heartening to us.

As you know, DOE has proposed shutdown of the Fast Flux Test Facility. Congress, in Fiscal Year 1991, authorized continued operation of FFTF and directed DOE to support an initiative by Washington State Governor Booth Gardner to seek alternatives to Government funding for the facility. DOE continues to support that initiative and with enthusiasm. I have assigned my Principal Deputy Assistant to personally follow that initiative and to provide the maximum support that the DOE can to that.

Westinghouse recently led a delegation, with our participation, to seek interest from the Japanese government and private institutions. In addition, Westinghouse representatives have recently met with members of the European nuclear research community. These efforts are just beginning; and the results will not be known for sometime. At this same time, the budget we have submitted provides only for the shutdown of FFTF, since the results are not yet available from the Governor's initiative.

Last, in support of Secretary Watkins' math and science education initiatives, we are proposing to establish a program to support nuclear engineering fellowships and scholarships, promote student interest in nuclear engineering careers, and assist university nuclear engineering departments in improving their curricula and equipment.

In conclusion, through the Department's support for civilian nuclear technology, as expressed in the NES, and enhanced concentration on the space and military applications of nuclear power, the United States can realize the full benefits of nuclear energy. I thank you for this opportunity to address you and will answer your questions.

[The prepared statement of Mr. Young follows:]

STATEMENT OF WILLIAM H. YOUNG
ASSISTANT SECRETARY FOR NUCLEAR ENERGY
BEFORE THE
HOUSE SCIENCE, SPACE AND TECHNOLOGY COMMITTEE
SUBCOMMITTEE ON ENERGY

MARCH 6, 1991

Madam Chairwoman, I am pleased to have this opportunity to present the Department of Energy's (DOE) programs and FY 1992 budget request.

OVERVIEW

The National Energy Strategy (NES), developed by the Secretary of Energy at the President's direction, provides focus to DOE's future policy and funding initiatives.

Based on public comment through hearings, written submissions, and publicly available reports, the NES provides a comprehensive, long range strategy for addressing the Nation's energy needs. The purpose of this strategy is to reconcile our need for adequate, secure, and competitively priced supplies of energy with safety, health, and environmental requirements.

The NES identifies an important and growing role for nuclear energy as part of a balanced array of energy sources for meeting the Nation's energy needs, especially the growing demand for electricity. One of DOE's primary responsibilities is to enable conditions which ensure an adequate supply of electricity to support economic growth. For many years, growth in U.S.

electricity demand has tracked growth in Gross National Product. NES projections indicate that the Nation could require as much as 275 gigawatts of additional generating capacity by 2010, about 85 percent of which will need to be baseload or intermediate capacity. Nuclear energy, which provided almost 20 percent of the Nation's electricity in 1990, can provide a significant portion of this needed baseload capacity.

The FY 1992 budget reflects the Administration's and DOE's strong commitment to nuclear power. In this context, the Office of Nuclear Energy (NE) has the responsibility for ensuring that nuclear power can continue to make a significant contribution to the Nation's energy needs by eliminating arbitrary and unwarranted obstacles to the use of nuclear energy.

Areas of Special Importance

Before I discuss the major program areas for which we are requesting funding in FY 1992, I want to highlight briefly four areas of special importance.

First, DOE has proposed legislation associated with the National Energy Strategy, which would contribute to the expansion of nuclear power by reforming the current licensing process and helping in the successful implementation of the Nuclear Waste Policy Act. We look forward to enactment of that legislation by the Congress.

Second, to provide the basis for commercial standardization, we are embarking on a program supporting first-of-a-kind engineering beyond design certification to develop plant designs beyond those needed for NRC safety certification. A key element of the program will be industry or market interest as evidenced by proposed levels of cost-sharing. Our goal is to commercially standardize the design of at least one Advanced Light Water Reactor (ALWR) by 1995, providing the basis for the next generation of nuclear powerplants. We are pleased to see that industry interest in support of this program seems to be developing.

Third, in cooperation with the user agencies, we are continuing the development of nuclear power sources for a variety of space applications. Key among these are the Radioisotope Thermoelectric Generators that have been used on many previous space missions. Our ability to assure an adequate supply of plutonium-238 isotope fuel is one of the main issues affecting our continued production of these generators. The Department is committed to bringing on-line the necessary facilities to process existing radioisotope fuel and to produce the new fuel that is needed to assure an adequate inventory of plutonium-238. To meet larger space power requirements, we are continuing to support development of the SP-100 space reactor system and alternative energy conversion technologies. We are also initiating efforts in support of the President's Space Exploration Initiative (SEI).

Fourth, in support of Secretary Watkins' math and science education initiatives, my organization is proposing to formally establish a "Nuclear Engineering Education Program". This program will support nuclear engineering fellowships and scholarships, promote student interest in nuclear engineering careers, and assist university nuclear engineering departments in improving their curricula and equipment. The FY 1992 budget will include $2.5 million of new money for this effort. In FY 1992, we also plan to continue sponsoring the "Nuclear Science & Engineering & Health Physics Fellowship Program," which supports graduate study and research at academic institutions and at DOE facilities in disciplines relevant to the NE program. We recently received a generous proposal from a private organization to join them in co-sponsoring a program in support of nuclear engineering education at several universities. We are working on finalizing the arrangement. This cooperative activity would allow us to leverage the costs and thus realize greater benefits from our own funding, and it could also serve as a model for similar joint endeavors with other private sector groups and companies.

FY 1992 Budget Highlights

Let me now highlight some of NE's programs in its FY 1992 budget request.

The more than 110 Light Water Reactors (LWR) licensed to operate within the United States constitute an existing resource base of 99 gigawatts of electric generating capacity. When these plants were licensed, however, existing regulations imposed an arbitrary 40-year limit on their operational lifetime. Today's technology can support the continued safe and efficient operation of these plants for an additional 20 years beyond the period of their current licenses. To prevent the premature loss of this resource, we have a program to demonstrate the technical feasibility of extending the operating life of existing Light Water Reactors and to secure license renewals for two lead plants. Although there are presently no regulations in place covering how license renewals are to be obtained, we, in cooperation with the industry, have established the basis for a new rule working with NRC. This rule was published on July 17, 1990, and NRC expects to issue this rule in final form this summer. The rule will be used for the review of the two lead plant applications which will be submitted in September 1991 and January 1992. Approvals are expected by the end of 1993.

Extending the operating lifetime of existing LWRs will help meet some of the Nation's need for generating capacity over the next several decades, but ALWRs, once commercialized, can make a greater contribution. During FY 1992 DOE and industry will continue with two cooperative, cost-shared programs to develop and certify ALWR designs. One program supports certification of two large (1300 MWe) evolutionary standardized designs, while the second supports two advanced passive mid-sized (600 MWe) standardized designs. The schedules for certification of those designs are currently being determined with the NRC, based upon the recent Commission decision on the level of detail required for certification with which, after much interaction with the NRC, we are satisfied. The objective of the National Energy Strategy is to have all four designs certified by 1995. We will be participating in interagency reviews of the schedules as they are developed. Further, we are working with industry to define the level of design detail -- beyond that needed for NRC safety certification -- that could provide commercial standardization.

As I mentioned earlier, reform of the licensing process is one of the actions necessary to enable the revitalization of nuclear power. NRC made important progress in this area in 1989 by issuing a licensing reform rule. However, in

November 1990 a Federal Court of Appeals struck down critical provisions relating to the post-construction hearing. While upholding other portions of the rule, the court noted that ultimate responsibility for changing the Atomic Energy Act's provisions with regard to post-construction hearings lies with Congress, not NRC. In order to have a clear statement of public policy on licensing, the Administration has proposed legislation containing provisions of the NRC rule, addressing emergency planning before construction, and avoiding the procedural delays of the currently unbounded post-construction hearing.

In the long-term, more advanced nuclear reactor technologies could provide safe, reliable, and cost-effective electric generating capacity. Two prominent advanced reactor designs are the Advanced Liquid Metal Reactor (ALMR) and the Modular High Temperature Gas Reactor (MHTGR).

The ALMR is a sodium-cooled reactor that may provide favorable safety and environmental features. Less waste heat is discharged because of its high temperature, which results in greater efficiency. Its low pressure enhances operating safety. With this reactor, it may be possible to consume a significant portion of the long-lived radioactive waste (such as plutonium, neptunium, and americium, known as actinides) created by other nuclear reactors. This could provide benefits of reduced volume, mass and toxicity of waste that must be transferred eventually to a geologic repository and delay the need for a second repository. In FY 1991, we began an initiative to determine the technical and economic feasibility of actinide burning as a way of processing commercial spent fuel. As part of this, an independent review will be conducted.

The MHTGR possesses two unique features. First, it uses fuel particles with high-temperature heat resistant coatings as a redundant and diverse barrier to the release of fission products. Second, it is the only reactor design which offers the potential for cogeneration applications for industrial and commercial customers.

Besides nuclear power technologies for civilian use, we also support the application of nuclear power technologies to meet a variety of space and defense power requirements. In tandem with NASA and the Department of Defense, NE is continuing programs to fabricate and produce Radioisotope Thermoelectric Generators (RTGs). RTGs helped make possible the photographs and data which the Voyager spacecraft sent. RTGs are also providing the power on the recently launched Galileo and Ulysses spacecrafts. RTGs will support NASA's Cassini and Comet Rendezvous Asteroid Flyby (CRAF) missions scheduled for launch in 1995 and 1996. We are also continuing to work in tandem with DOD and NASA to develop the SP-100 space reactor power system at full budget level. We plan to support the President's SEI by studying applications for nuclear propulsion and nuclear power on the Moon and on Mars, and by studying innovative technologies in life-protective shielding, fuels, and advanced materials, among others.

We are responsible for the operation and maintenance of an array of facilities which support the current reactor programs' research, development, testing, and evaluation of nuclear materials and system and component technologies. These facilities are also made available to other DOE programs, industry, other Government agencies, and other governments.

NUCLEAR ENERGY RESEARCH AND DEVELOPMENT

The funding request for Nuclear Energy R&D programs is contained in the following table:

Program Element	Budget Authority ($ in Millions) FY 1991 Appropriation	Budget Authority ($ in Millions) FY 1992 Request
Nuclear Energy R&D		
Light Water Reactors	38.2	62.5
Advanced Reactor R&D	56.7	49.5
Space Reactor Power Systems	33.3	56.0
Space Exploration Initiative	0.0	30.0
Advanced Radioisotope Power Systems	75.0	56.0
Facilities	91.9*	127.8*
Program Direction	8.7	16.1
Total	304.0	398.0

* FY 1991 funding for FFTF included in the Environmental Restoration and Waste Management budget. FY 1992 amount includes FFTF.

LIGHT WATER REACTORS

The LWR program is a comprehensive undertaking to meet goals related to nuclear power as expressed in the NES. One of these goals is to ensure an adequate electricity supply to meet the future electricity demand of the Nation's economy. NE, in cooperation with industry and in concert with NRC, focuses its program efforts on two objectives:

- Removal of institutional and regulatory obstacles preventing nuclear power from competing freely in the marketplace.
- Support for R&D efforts to improve the LWR option and thus facilitate its continuing contribution to the Nation's energy supply system.

Within these broad objectives, the NE program has two specific objectives bearing directly on the supply of nuclear-generated electricity and the viability of the nuclear power industry:

- Obtain a revision of the licensing process which limits the operational lifetime of the 112 currently operating LWR powerplants to 40 years and thereby ensure that the existing 99 gigawatts of capacity is not prematurely retired because of an arbitrary operational lifetime.
- Achieve commercial availability by 1995 of standardized ALWRs which will permit orders to commence by 1995 and thereby enable nuclear power to contribute to the additional electricity generating capacity projected to be needed between 1990 and 2010.

The $62.5 million which NE requests for FY 1992 will help achieve these objectives.

Licensed Light Water Reactors

NE has a vigorous program to demonstrate the feasibility of extended operating life of existing LWR powerplants and to secure license renewals for two lead plants by 1993. The 112 LWRs licensed to operate within the United States constitute an existing resource of 99 GWe of electrical generating capacity. However, the existing licensing process imposes an arbitrary 40-year limit on their operational lifetime. Today's technology can support the continued safe and efficient operation of these powerplants for 20 years beyond the period of their current licenses.

To this end, NE and utilities are continuing cofunding a powerplant life extension program which has made considerable progress over the past year. We prepared and submitted to the NRC 11 technical reports on critical plant equipment in order to establish technical standards and criteria. Dialogue with the NRC will continue. After issuing a proposed license renewal rule and initiating a supporting environmental rulemaking in July 1990, NRC has scheduled issuance of the final license renewal rule and the supporting environmental rule for 1991 and 1992.

Work is continuing on demonstrating the feasibility of extending the operating lifetimes of LWR powerplants. In late 1991, the plant owners expect to submit the first license renewal applications to the NRC to extend the lives of the Yankee Rowe and Monticello nuclear powerplants for 20 years. In FY 1992, NE will respond to policy and technical issues raised by NRC during the course of its review and evaluation of these applications. We anticipate NRC approval by late 1993.

A major program activity is demonstrating the adequacy of the Yankee Rowe Reactor Pressure Vessel (RPV) for the renewal term. Owners of Yankee Rowe have instituted a three-prong effort to provide the plant-specific technical data and analysis to demonstrate RPV integrity for the renewal term. They are also developing plans to anneal or replace the RPV if testing and inspection show either step to be necessary. We are confident that this approach provides the analysis and options necessary to achieve license renewal for Yankee.

Advanced Light Water Reactors

NE and industry have implemented several cost-sharing programs to incorporate lessons learned from the three-and-a-half decades of operation of licensed LWRs in the development of ALWRs. The lessons learned will be applied to evolutionary powerplants designed to generate 1250 to 1350 megawatts (MWe) of electricity, and to advanced mid-size powerplants designed to generate approximately 600 megawatts.

One major aim of the NE program is to demonstrate the viability of the nuclear powerplant design certification process by obtaining NRC certification of two evolutionary ALWR designs. These are the GE ABWR design, developed in collaboration with the Japanese, and the Combustion Engineering System 80+

advanced pressurized water reactor (APWR) design, based on the modernization of the Palo Verde station System 80.

The NRC is giving both powerplant designs an intensive review. NRC final design approval of the ABWR and the System 80+, followed by their certification, will provide needed demonstration of this process.

Another major aim of the NE program is to develop and certify mid-size ALWR designs which not only build on the extensive experience of the three-and-a-half decades of LWR operations, but also take advantage of innovations in design and construction especially suited to smaller plants. Such features include simpler designs; more passive safety features (e.g., gravity cooling by water to remove decay heat and cool reactor cores in an emergency); and factory fabrication of components and modular deployment which reduce construction time.

The technical and economic feasibility of the Westinghouse AP 600 and GE Simplified Boiling Water Reactor (SBWR) mid-size powerplant designs has been confirmed by an extensive design and testing program. Safety Analysis Reports (SAR) will be prepared by 1992 under cost-sharing arrangements signed with both companies in 1990. Westinghouse will submit its SAR on the AP 600 to NRC in July 1992. We are targeting final design approval in 1994 and design certification in 1995. The GE SBWR is on a similar schedule.

In response to requests in House and Senate reports accompanying the FY 1991 Energy and Water Development Appropriations Act, NE evaluated the need for

Federal funding of first-of-a-kind engineering for ALWRs and has proposed such a program in the FY 1992 budget request. This program would perform first-of-a-kind engineering beyond design certification in order to provide commercial standardization, which, besides facilitating the use of standardized designs, will permit more reliable estimates of costs and construction schedules. NE proposes to fund the program on a cost-shared basis with utilities and to include provisions for cost recovery.

NE's Advanced Reactor Severe Accident Program (ARSAP) is supporting programs to assist development of the ALWR requirements document, and of ALWR certification by providing updated tools for evaluating severe accidents and by making recommendations to resolve severe accident issues. The program applies methods and technology developed from DOE's and NRC's severe accident programs. In FY 1992, the program will continue to shift the emphasis of its support from evolutionary to mid-sized ALWR powerplants.

We will also demonstrate the early site approval licensing process by obtaining an NRC Early Site Permit by 1995. This program addresses key issues raised by the new NRC licensing process. DOE has issued a Request for Proposals to initiate a cost-shared project with industry. Since the Early Site Approval program complements the program demonstrating design certification, it is apparent that DOE is comprehensively addressing regulatory obstacles to new plant orders.

Powerplant Safety

NE has made progress in two other important areas. First, as it has successfully completed its R&D program at Three Mile Island (TMI), NE requests no additional funds for those activities. The safe arrival at the Idaho National Engineering Laboratory (INEL) of the final shipment of damaged fuel from the TMI Unit 2 marked the completion of DOE's ten-year program. The program successfully demonstrated first-of-a-kind technology to disassemble and defuel the reactor, manage unusual waste products, and transport the damaged core to INEL for research and storage. The results of this research have led to a better understanding of major reactor accidents and are helping to resolve severe accident issues facing future reactors.

DOE's efforts to improve the safety of nuclear facilities have been responsive to developments in the international community. In September 1989, the Secretary proposed that the United States and the Soviet Union join in a cooperative effort to improve the safety of civilian nuclear powerplants. Congress provided $7 million in FY 1991 to support this program. Work on this program is scheduled to continue through 1992. No additional funding is required in FY 1992 because previously appropriated funds are adequate to bring this effort to a successful conclusion.

The U.S./Soviet Operational Safety Initiative supports improvements in Soviet operating practices as the most practical, short-term way to enhance Soviet nuclear powerplant safety. In a meeting in Moscow in March 1990, the U.S. and U.S.S.R. agreed to a detailed approach for implementing the initiative. The approach includes an organizational framework for the Initiative, comprised of an Executive Steering Committee and three Expert Working Groups, one each for operating instructions, training, and management and operational controls.

Since the March meeting, the Institute for Nuclear Power Operations (INPO) and U.S. utility experts have worked jointly with their Soviet counterparts to demonstrate and convey U.S. practices to the Soviets. Experts have visited plants in both countries. During this time, the experts have jointly developed detailed work plans to implement these practices at a Soviet reactor.

In November 1990, the workplans to improve the operational safety of the Soviet reactors were approved by the Executive Steering Committee. The plans indicate the specific products (such as symptom based operating instructions) to be developed in 1991, as well as the plans and schedules for implementation of safety improvements at Unit #4 at the Novovoronezh nuclear powerplant site beginning by the end of 1991. The success of this cooperative effort can have a significant positive effect on Soviet energy production by reducing accident potential and improving public confidence.

ADVANCED REACTOR RESEARCH AND DEVELOPMENT

NE requests $49.5 million in FY 1992 for advanced reactor R&D. NE's programs address two types of advanced reactors: MHTGR and ALMR with its associated integrated fuel cycle. The benefits of R&D investments in advanced reactor systems are increased by cooperative, cost-shared programs with other countries and with industry.

Both of these advanced reactors have the potential to improve safety by featuring systems which depend on physical laws and the properties of materials rather than on more complicated engineered systems typical of current generation reactors. In addition, both have several other advantages: simplified and standardized designs; factory fabrication of components, with improved quality control; shorter construction schedules and lower construction costs; and modularity, which gives utilities more flexibility to meet load growth.

A specific advantage of the ALMR is its potential capability to use as fuel the actinides in nuclear waste, especially spent fuel from LWRs and thereby extend uranium resources, and reduce the volume, mass and toxicity of waste that must be transferred eventually to a geologic repository. In addition, the ALMR has the capability to withstand most severe accident conditions without the need for operator action or for evacuating or sheltering anyone who lives or works outside the powerplant boundary. Specific advantages for the MHTGR are its unique capabilities to achieve a safe shutdown without radioactive release under all conceivable transient and accident conditions and to provide high-temperature process heat for industrial and commercial applications.

Advanced Liquid Metal Reactor

In FY 1992 NE plans to continue support for development of the ALMR and its related Integral Fast Reactor (IFR) metal fuel cycle. Key activities are to demonstrate the technical capability and economic feasibility of the IFR concept; to test major components; and, to continue design and licensing activities. A team consisting of members from the groups and countries shown below will complete these efforts.

Industry

Babcock & Wilcox
Bechtel
Burns & Roe
Byron Jackson
Combustion Engineering
Foster Wheeler
General Electric Company
Rockwell International
United Engineering & Construction
Westinghouse Electric Corporation

University

Massachusetts Institute of Technology

National Laboratories

Argonne National Laboratory
Energy Technology Engineering Center
Hanford Engineering Development Laboratory
Oak Ridge National Laboratory

Other Countries

France
Germany
Great Britain
Italy
Japan

The Electric Power Research Institute and utility and industry personnel and groups will review ALMR program plans and progress to advise NE on program direction, technology transfer, and data requirements to help establish cooperative NE and private-sector programs to design and construct prototype commercial plants and to obtain NRC certification.

NE will work to resolve important ALMR reactor plant licensing issues with NRC. These issues include siting source term, containment design, accidents for use in safety analyses, and emergency planning. Design efforts will focus on establishing the economic and technical bases to using ALMRs for actinide recycle. As part of this, an independent review will be conducted.

The prototype demonstration of the IFR pyroprocessing of LMR spent fuel will continue at Argonne National Laboratory-West (ANL-W) in FY 1992. According to program plans, NE will determine steady-state and transient performance of ALMR metal fuels; develop pyroprocessing of LWR spent fuel; and develop reactor core technology and analytical tools; conduct tests to meet safety and licensing requirements.

NE will continue cooperative international efforts in FY 1992 in studying LMR oxide fuel cycle; developing fuel separation technology, remote systems technology, and shielding; collecting reliability data from existing domestic and foreign liquid metal reactors; and testing advanced steam generator models.

By 1995, the technical and economic feasibility and licensability of using ALMR technology for consuming radioactive waste (actinide recycle) could be determined. This could provide an emerging technical basis for this technology's possible contribution to the long-term radioactive-waste management system.

Modular High Temperature Gas Reactor

In FY 1992 the MHTGR program plans to demonstrate two critical features of the MHTGR concept: fuel quality and performance, and heat removal from the core and pressure vessel. The following specific activities will be emphasized in FY 1992: completion of the second of three major fission product transport tests in the COMEDIE Loop in France, continuation of fuel irradiation testing in the High Flux Isotope Reactor, and the initiation of post-accident simulation testing of irradiated fuel. In addition, NE will give some attention to assessing the direct cycle gas-turbine and applications of process heat. NE will also continue to bring the results of R&D to bear on licensing issues before NRC. NE will continue cooperative R&D efforts under current agreements with France, German, Japan, and the United Kingdom.

Under a joint program with the Office of New Production Reactors, NE is integrating civilian with defense R&D in assessing MHTGR technology for use in the New Production Reactor. This joint program has identified approximately $100 million worth of activities in FY 1992 which would advance civilian R&D in several areas. These areas of commonality include design work, project infrastructure, technology development, plant design, and safety issue resolution and design acceptance.

ADVANCED RADIOISOTOPE POWER SYSTEMS

The purpose of the Advanced Radioisotope Power Systems program is to produce radioisotope power systems for U.S. civilian and military terrestrial and space missions. Radioisotope power systems, in use for almost three decades, are proven, reliable, and maintenance-free power supplies capable of producing up to one KWe for tens of years.

Such systems are the cornerstone of the Nation's space nuclear power program requiring low levels of electric power. Radioisotope power supplies recently enabled the Galileo spacecraft to transmit pictures of the far side of the Moon. RTGs are also powering the Ulysses spacecraft on its voyage to the polar regions of the Sun. Current radioisotope power projects include NASA's CRAF and Cassini missions, scheduled for launch in 1995 and 1996, as well as special terrestrial applications for DOD.

The Advanced Radioisotope Power System program provides base support for radioisotope fuel and heat source development, production and qualification; nuclear safety analysis and testing; power converter system development; and all aspects of manufacturing, quality assurance, reliability, and operational safety for radioisotope power systems.

NE has reduced its funding request from $75.1 million in FY 1991 to $56.0 million in FY 1992. This reduction reflects the fact that efforts to restore production facilities started in FY 1990 and FY 1991 are nearing completion and that the construction of the Radioisotope Power System Facility is being deferred. The request does include increased funding for production of new plutonium-238 (Pu-238), for processing of existing Pu-238 in support of the CRAF and Cassini missions, and to begin replenishing the Pu-238 stockpile for future NASA and DOD missions, including SEI, which are expected to use radioisotope power systems. NASA and DOD jointly fund these projects with NE. There are three main activities within the advanced radioisotope program: radioisotope thermoelectric generators, Pu-238 production, and special applications.

Radioisotope Thermoelectric Generators

NE programs in FY 1992 will continue to develop systems using RTGs and to provide improved RTG power systems and related technologies for future missions. In these efforts, NE works to improve heat source and converter performance and safety, to improve production efficiencies and reduce costs, and to pursue long-term technology development, especially in the thermoelectric materials area.

The emphasis in near-term efforts supports the CRAF and Cassini missions directed by NASA. To learn from the experience acquired from earlier RTGs, an FY 1991 effort will dismantle and analyze the qualification RTG for the Galileo and Ulysses missions after successful long-term life testing of over 53,000 hours. The Pu-238 fuel will be recycled for use in the CRAF and Cassini missions. The backup Ulysses flight RTG has also been returned to monitored storage until it is needed for the CRAF mission.

NE will focus its efforts in FY 1992 on establishing manufacturing operations for fabrication of converter and heat source components for the CRAF and Cassini missions. Plans for FY 1991 call for the systems contractor to begin designing and qualifying the manufacturing line, developing operating procedures, acquiring materials and equipment, and selecting and qualifying personnel. NE plans to start full-scale production of all converter elements in FY 1992 in order to provide the first converters for fueling starting in FY 1993. The fabrication of the converters for the CRAF/Cassini missions is now planned to be conducted at the existing Mound facility instead of at the Radioisotope Power System Facility that is being deferred at Hanford. The Systems Contractor will coordinate its activities with NASA's Jet Propulsion Laboratory.

In planning for future NASA missions, NE continues to develop an advanced modular RTG (MOD-RTG) that will ensure ready adaptability to a wide range of power levels. Work will continue in 1991 and 1992 on a new multicouple design to be made into a ground demonstration system assembly in FY 1992. A potential near-term application that would be pursued in concert with NASA is the Solar Probe mission. This mission has been identified as one of NASA's major missions in its current five-year strategic plan. NE will continue to support NASA in studies of future missions, including the possible use of these MOD-RTGs or the use of dynamic radioisotope power systems, which can provide several KWe of electrical power for SEI missions.

Pu-238 Production

A key issue on the use of RTGs is assuring an adequate supply of Pu-238. The facilities to process Pu-238 were placed on standby in the early 1980s and are in the process of being reactivated. NE began preparations in late FY 1990 and is continuing in FY 1991 to bring the Pu-238 production and processing facilities at Savannah River to an operational state. Neptunium-237 (Np-237) target fabrication facilities need to become operational in FY 1991 to provide targets for insertion into the reactors starting in FY 1992. Resumption of reactor operations, including Np-237 target irradiations, and the Pu-238 processing facilities will provide Pu-238 for the CRAF and Cassini missions in early FY 1993 and will begin replenishing the strategic inventory required for future NASA and DOD missions, including SEI. These production and support activities will continue into the future to meet projected demands for these materials.

Special Applications

NE's special applications program continues to develop and demonstrate technologies and refurbish existing power supplies in fulfillment of its obligations to provide RTGs for terrestrial national defense missions. In FY 1991, the program will support design and integration studies for specific missions and test the reliability of system improvements, including a 2-watts-electric-heated prototype RTG. It will issue a preliminary SAR on this RTG in FY 1991 to qualify the unit for future production. NE will also continue to provide refurbishment and production services for high-performance generators for DOD; however, fabrication of RTGs depends on DOD mission requirements and program decisions.

SPACE REACTOR POWER SYSTEMS

For power levels in excess of those that can be satisfied with radioisotope systems, the Department is supporting the development of Space Reactor Power Systems. As with the radioisotopes programs, these space reactor systems are being developed to meet the requirements of other agencies. The Department pursues these efforts as part of its charter under the Atomic Energy Act.

This program embraces two main activities, the tri-agency SP-100 space reactor power system that is the principal thrust of the Nation's space reactor efforts, and a backup effort on thermionic reactor systems technology. Both programs are supported and jointly funded by NASA and/or DOD. NE's FY 1992 funding request of $56.0 million, an increase of $22.7 million over its FY 1991 appropriation, enables DOE to contribute its share to the SP-100 program under the amended Memorandum of Agreement signed in late 1989 with NASA and DOD.

SP-100 Space Reactor

The SP-100 reactor system aims to develop, demonstrate, and make available space nuclear reactor technology capable of generating 10's to 100's of kilowatts, thus flexibly meeting the power requirements of a variety of civilian and military applications in the early 2000s and beyond. The program is in its sixth year of designing and engineering a ground test reactor and conducting tests of nuclear fuel, materials, and components.

The SP-100 Steering Committee, with representatives from the three funding agencies and the Air Force, has restructured the program's development plan to address program funding reductions over the past several years. The Committee decided to proceed directly to develop a flight-qualified system ready for space use rather than to pursue the current sequential approach of ground reactor testing followed by a flight qualification phase. The plan now calls for ground testing to be done later in the program, in concert with space qualification efforts. Without this restructuring, the budget reductions would have delayed system availability until well into the first decade of the next century; restructuring will accelerate the availability of an SP-100 system by several years, if the needed funding profile is adopted by Congress.

According to the restructured plan, the program will simultaneously develop all required subsystems, not just the reactor and converter, and update the system design in the mid 1990s, when NASA and DOD can better define mission-specific requirements. NASA and DOD have indicated that a flight-qualified system ready around the turn of the century is compatible with their program schedules.

As a result of this restructuring, the near term focus of the program is on component development of the thermoelectric cells and other key technologies. Performance testing of a near prototypic thermoelectric conversion cell and fabrication of key reactor components for lifetime testing will occur in FY 1991.

In FY 1992, testing of these materials and reactor components under prototypic conditions will begin. In developing components and demonstrating component lifetime, the program will focus on completing a test of the prototypic SP-100 pump and power converter by 1996.

Thermionic Reactor System Technology

Because thermionic reactor systems may have some survivability advantages for military applications in space, NE is continuing its support of the Thermionic Fuel Element (TFE) verification program that was initiated to resolve the issues that led to the non-selection of thermionics for SP-100. NE coordinates its efforts with those of the Air Force, which is conducting nuclear thermionic power system studies in 1991. These studies together with the TFE program form the basis for an expanded thermionic systems technology program that the Department is preparing to initiate in FY 1992. This effort would bring thermionic technology closer to maturity.

The TFE program includes insulator, fueled emitter, collector, and thermionic converter tests in irradiation facilities. It will continue component testing initiated in recent years and is expected to culminate with a prototypic test of a six-cell TFE in a fast reactor environment in FY 1995.

SPACE EXPLORATION INITIATIVE

In addition to the radioisotope thermoelectric generator efforts and the continuing work on space reactors, the Department is requesting $30 million in FY 1992 to initiate a cooperative, cofunded program with NASA to support the Space Exploration Initiative (SEI). This program is within the scope of the broad Memorandum of Understanding between DOE and NASA that was signed in FY 1990, but did not specify particular programs or funding levels. This new program aims to develop nuclear propulsion and power systems and nonnuclear technologies for the manned exploration of the Moon and Mars. At the same time, the program recognizes that many of the concepts for propulsion and power may have terrestrial applications in the twenty-first century and can help strengthen the Nation's technological lead in nuclear and space technologies.

The program will initiate its efforts to develop technologies for this purpose by searching for new approaches and technologies.

Efforts on nuclear propulsion are being initiated as one of the critical technologies for SEI because of its relative advantages over chemical propulsion. These advantages include the potential for shorter trip times, thereby reducing radiation exposure to the astronauts, and for smaller system mass resulting in lower launch costs. In its first year, this program will evaluate nuclear propulsion concepts and associated technologies and will initiate development of key long term efforts. The program will also evaluate the facilities that will be needed for fuel fabrication, irradiation testing, and integrated propulsion engine testing and will initiate National Environmental Policy Act and other documentation that will be needed to conduct the program.

Surface electrical power will play a critical and enabling role in lunar and Mars operations. Though radioisotope and reactor space power development is funded in the other space budget categories, an effort will be initiated under the SEI support category to conduct design studies and technology efforts directed specifically to adopting or modifying these systems for lunar or Mars surface operation. For example, efforts will examine RTGs in the power range of a few hundred watts and SP-100 in the range of 10's to 100's of kilowatts. The Turbine Energy Conversion System will be evaluated for the intermediate level of 1-10 KWe.

DOE has a broad expertise and facility base that may be useful in support of the SEI. A general subcategory of concepts and technologies will be undertaken to pursue five to six of the most promising technologies; for example, high temperature nuclear fuels in support of nuclear propulsion, advanced non-nuclear power concepts, human health/radiation effects, and advanced computing. These efforts will be broad based across the Department rather than just in nuclear energy.

FACILITIES

NE operates some of the finest facilities in the world to provide the safe and reliable experiment and test capabilities needed to develop civilian fission and fusion nuclear power technologies and systems, to support space and defense missions requiring nuclear power, and to support other DOE, interagency, nationwide, and international programs. NE is requesting $127.8 million for support of the nuclear energy facilities for which it is responsible in FY 1992.

While fulfilling its experimental and test missions, NE's facilities have compiled an outstanding record of safety and environmental compliance over the years. Reflecting DOE's commitment to maintain this record, NE is strengthening its management efforts to ensure the safe, environmentally acceptable, and reliable operation of its facilities. These efforts build on improvements in management and operations already made in response to the reviews by the National Academy of Sciences; and DOE's Advisory Committee for Nuclear Facility Safety; they fully implement applicable Institute of Nuclear Power Operations (INPO) good practices. This record of performance was taken into account in the decision last year to transfer to NE responsibility for operating the Office of Energy Research nuclear facilities.

In FY 1992, the facilities program plans to emphasize the following activities: the initiation of the IFR fuel cycle demonstration with metal fuel recovery and fabrication in the Fuel Cycle Facility, the conclusion of Tower Shielding Facility operations in support of the joint DOE/PNC shielding program, and the performance of surveillance and maintenance on Oak Ridge National Laboratory.

Major actions to enhance the management and operations of NE experiment and test facilities include (1) using probabilistic risk assessments in safety analyses as an additional tool in the reactor safety decision-making process, (2) conducting studies on reactor operational lifetimes, (3) implementing procedures at NE's operating facilities in order to ensure the adoption of INPO good practices at our facilities, (4) reemphasizing timely required equipment upgrades in order to sustain safe and reliable facility operations, and (5) increasing independent oversight of those operations.

NE has also improved the cost effectiveness of its facilities by increasing their efficiency and by closing nonessential operations. In one instance, the privately-financed electric generation system constructed at the Energy Technology Engineering Center, which began operation in 1988, will produce revenues from the sale of electricity during advanced steam generator performance and endurance testing. In another case, the Zero Power Plutonium Reactor has been placed in a standby mode for lack of current program work.

Out of the same concern for cost effectiveness, NE conducted a comprehensive evaluation of long-term missions of the Fast Flux Test Facility (FFTF) at

Hanford, Washington. It determined that the amount of work done there, predominantly work done under the Advanced Reactor Program, does not justify the expense of its continued operation and that essential testing done in the FFTF could be done in the Experimental Breeder Reactor-II (EBR-II). Congress, in Fiscal Year 1991, authorized continued operation of FFTF and directed the Department to support an initiative by Washington State Governor Booth Gardner to seek alternatives to Government funding for the facility. DOE continues to support that initiative.

Governor Gardner enlisted the help of Westinghouse, the designer, builder and operator of FFTF under a contract with the Department of Energy, to seek interest in an international program of research using the FFTF as a research center. Westinghouse recently led a delegation, with Department of Energy participation, to seek interest from the Japanese government and private institutions. In addition, Westinghouse representatives have recently met with members of the European nuclear research community. These efforts are just beginning; the results will not be known for sometime. At the same time, the FY 1992 budget provides only for the shutdown of FFTF since results are not yet available from the Governor's initiative.

The major sites and the major facilities funded by the NE FY 1992 budget request are shown on page 32.

Argonne National Laboratory-West (ANL-W), near Idaho Falls, Idaho

EBR-II	Experimental Breeder Reactor-II
FCF	Fuel Cycle Facility (Hot Fuel Examination Facility-S[HFEF-S])
FMF	Fuel Manufacturing Facility
HFEF	Hot Fuel Examination Facility
TREAT	Transient Reactor Test Facility
ZPPR	Zero Power Physics Reactor

Westinghouse Hanford Company (WHC), near Richland, Washington

FFTF	Fast Flux Test Facility
FMEF	Fuels and Materials Examination Facility

Energy Technology Engineering Center (ETEC), near Canoga Park, California

ANL-W is the technology center for the IFR program to demonstrate metal fuel processing, fuel fabrication, and waste treatment for the closed metal fuel cycle. Major activities at this site in FY 1991 include:

EBR-II: passive safety testing; fabricating advanced metal driver and experimental fuel for EBR-II, performance of binary and ternary metal fuels

FCF: completing modifications and starting checkout operations for metal fuel fabrication, reprocessing and waste treatment

TREAT: safety testing

Activities planned for FY 1992 include continued performance assessment of binary and ternary metal fuels in EBR-II, fabrication of metal fuel reprocessing and waste treatment operations in the metal fuel, processing systems in the FCF, safety testing in TREAT, and continued advanced reactor safety testing in EBR-II.

ETEC conducts non-nuclear tests of liquid metal components and emphasizes steam generator performance and endurance tests at the Sodium Component Test Installation. It also conducts tests in support of other DOE and industry programs, and, for that reason, more than half of the funding for operations is derived from sources outside the NE R&D budget.

NE plans to begin testing the double-wall tube steam generator under a cooperative U.S.-Japan contract in FY 1991 and to conclude it in FY 1993 at ETEC. NE also operates the Tower Shielding Facility at Oak Ridge to support cooperative U.S.-Japan shielding development programs and the Integrated Equipment Test Facility at Oak Ridge for use in various fuel cycle and remote technology programs.

CONCLUSION

The nuclear industry is experiencing many exciting developments which we believe will lead to revitalizing the nuclear option. These developments, ranging from new breakthroughs in technologies, to improvements regarding the regulatory process, to improvements in space and military applications, point to gradual but distinct growth in the nuclear industry.

Through the Department's support for civilian nuclear technology as expressed in the National Energy Strategy, and enhanced concentration on the space and military applications of nuclear power, the United States can realize the full benefits of nuclear power. I thank you for this opportunity to address you and would be glad to answer your questions.

Mrs. **Lloyd**. Thank you very much, Mr. Young. I believe we'll go ahead with our questioning with you, then we—

Mr. Aldrich has a tight schedule, so please proceed, Mr. Aldrich.

STATEMENT OF ARNOLD D. ALDRICH, ASSOCIATE ADMINISTRATOR, AERONAUTICS, EXPLORATION AND TECHNOLOGY, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Mr. **Aldrich**. At your pleasure, Madam Chairman. I would be able to do it in any sequence that most pleases the committee.

Mrs. **Lloyd**. Please go ahead.

Mr. **Aldrich**. Thank you. I appreciate the opportunity to restate to the Subcommittee NASA's firm commitment on space nuclear power development.

The 21st century missions being planned by NASA encompass wide-ranging solar system science and exploration objectives. New systems and operational modes are being assessed and a common critical element identified in these efforts is the vital need for safe, reliable, long-life nuclear power sources. Nuclear power and propulsion are among the highest priority items in our ongoing Exploration Technology program. These technologies have been strongly endorsed by every major review of the Space Exploration Initiative, and we believe the candidate architectures soon to be proposed by General Thomas Stafford's Synthesis Group will also stress the critical need for nuclear power and nuclear propulsion systems.

Our lunar mission studies consistently indicate that significant surface operations will be enabled by the use of high capacity nuclear reactor power systems. Lunar in-situ resource utilization is an example of an energy-intensive activity, requiring large amounts of electrical and thermal power. The reactor technology being developed in the DOE-managed SP–100 program offers a highly promising approach to meet the basic requisites of high power density and performance, compactness, long-life potential and versatility.

Future developments in nuclear propulsion potentially offer many operational advantages to support human solar system exploration. Studies demonstrate that a dramatic reduction of overall space vehicle weight can result from the use of nuclear thermal propulsion systems. Shortened trip times for human Mars missions and efficient round-trip operations for crew transit and unmanned cargo delivery are features of vital importance to our mission planning.

At the lower end of the power spectrum, there is also a NASA requirement for a compact, lightweight power system to support robotic system operations in very long duration, deep space scientific probes. The benefits of shortened trip times, alleviation of current tight launch window constraints, and the elimination of gravity-assist maneuvers are but some of the operational advantages provided by nuclear electric propulsion. Advanced isotope systems can satisfy the few kilowatts of power needed at the lowest end of the spectrum, while the basic SP–100 thermoelectric power system will meet the requirements in the tens of kilowatts range required for nuclear propulsion.

In summary, our studies have shown that the space vehicle weight reductions and increased operational flexibilities made possible by nuclear power and nuclear propulsion systems will have a dramatic impact on the cost and mission success of future NASA exploration programs. NASA recognizes that these technology development programs are expensive and require lengthy development spans. However, NASA studies, as well as those of other organizations, indicate that the use of nuclear systems is essential to the conduct of many of these important missions.

Thank you, Madam Chairman. That concludes my remarks. I would be happy also to answer questions from the subcommittee.

[The prepared statement of Mr. Aldrich follows:]

Statement
of
Arnold D. Aldrich
Associate Administrator for
Aeronautics, Exploration and Technology

before the

Subcommittee on Energy Research and Development
Committee on Science, Space, and Technology
House of Representatives

Madam Chairman and Members of the Subcommittee:

I appreciate this opportunity to restate to the Subcommittee NASA's continuing, firm commitment to space nuclear power systems development and to discuss their importance and potential application to future civil space missions.

The potential 21st Century missions being investigated by NASA encompass ambitious, wide-ranging solar system science and exploration objectives. In ongoing systems architecture study efforts, new systems and operational modes are being identified and assessed to meet NASA's potential future robotic science and human exploration mission objectives. A common, critical element identified in these studies is the need for safe, highly reliable, long-life nuclear power sources that are capable of providing the electrical power for sustained lunar and planetary surface operations and the thermal or electrical power capability required for advanced propulsion systems. Surface nuclear power and nuclear propulsion are considered critical and are among our highest priority items in the ongoing space exploration technology program. Although final independent analyses from the Synthesis Committee, headed by General Thomas Stafford, are not expected until later this month, we are confident that the candidate architectures proposed by this Committee and the resulting technology recommendations will also stress the critical need for nuclear power and propulsion systems. I will discuss potential NASA operational needs to highlight what benefits we presently foresee from the utilization of nuclear technology.

Mission studies continue to identify the need to generate, with a high degree of reliability and for extended duty cycles (e.g., a decade or more), the vast amounts of power that could enable desired lunar and Mars surface operations activities. These studies indicate that sustained lunar surface operations (i.e. throughout the 14 day lunar night cycle) can be enabled only by the on-site use of high capacity nuclear reactor power generation systems. For example, in-situ resources utilization, considered a primary feature of many sustained surface operations scenarios, is an energy-intensive activity, necessitating the generation of large amounts of electrical and thermal power. Reactor power systems meet the basic requisites of high power density and performance, compactness, long-life potential, and versatility. The compact, fast spectrum reactor being developed in the DOE-managed SP-100 program offers a promising approach to achieving the high capacity power system capability required.

The DOE testimony has indicated that significant technical progress has been made in the SP-100 program. I recently had the opportunity to review the program in some depth and concur with the assessment of the technical progress. Also, as a member of the SP-100 Steering Committee, I participated in the recent decision to restructure program activities and I feel that the changes made are timely and appropriate. In NASA's efforts to improve power conversion system efficiency and reduce system weight, we have made significant progress in the areas of thermoelectric material performance, Stirling power converter development, refractory alloys engineering data base, and advanced waste heat radiator concepts and materials development. Thermoelectric material performance gains of 20-30% have been confirmed in repeated tests; as a result, goals associated with SP-100 system performance have been achieved for the thermoelectric cell. Additional gains are being pursued in Jet Propulsion Laboratory (JPL) research efforts. Stirling power converter technology development is proceeding on schedule with the individual cold end and hot end component test assemblies for a Space Stirling Power Converter scheduled to be in test during this fiscal year.

Let me now turn to nuclear propulsion. The operational advantages of nuclear propulsion systems in support of exploration missions are being assessed by our mission planners. These studies show that a dramatic reduction in overall space vehicle weight (and therefore weight required to be launched into earth orbit) can result from the use of nuclear thermal rockets and/or nuclear-electric propulsion systems. Shortened trip times for human interplanetary operations and efficient round-trip operations for crew and cargo are features of vital interest in current planning for the Space Exploration Initiative. A nuclear propulsion project office has been established at the Lewis Research Center to assist in the coordination of our nuclear propulsion research activities with the DOE and DoD. The features and technical status of alternative nuclear thermal propulsion concepts are being addressed in a comprehensive interagency nuclear propulsion technology program planning effort. Funding for significant nuclear propulsion technology efforts has been requested as part of NASA's FY 1992 budget.

Shifting now to the lower end of the power spectrum, there is a need for compact, lightweight power systems ranging from a few kilowatts of electrical power for support of surface operations and robotic free-flyer spacecraft to greater than 10's of kilowatts for potential high efficiency electric propulsion mission operations that could support very long duration, deep space scientific missions. Shortened trip times, alleviation of current tight launch window constraints, and elimination of gravity-assist maneuvers necessitated by chemical propulsion performance capabilities, are but some of the operational advantages that could be provided by higher performance nuclear propulsion systems. The excess power delivered from the reactor power source could be made available during the mission for use by the planetary spacecraft systems to allow enhanced scientific return, e.g., increased data rates, increased radio frequency signal depth in planetary atmospheres, additional sensor cooling for larger instruments, and use of lasers and radar for scientific research. Potential future Earth-oriented applications could support space vehicles involved in air and ocean radar traffic control, commercial microgravity materials processing, and observations and communications platforms. For science missions, advanced isotope power systems are needed to satisfy the few kilowatts of power needed at the lower end of this spectrum, while the baseline SP-100 thermoelectric power system can satisfy the power requirements in the 10's of kilowatts needed for systems such as electrical propulsion.

In summary, our studies have shown that space vehicle weight reduction and increased operational flexibilities such as expanded launch windows made possible by surface nuclear power and by nuclear propulsion systems will have a dramatic impact on the cost of conducting NASA's future exploration missions. NASA recognizes that technology development programs in nuclear power and propulsion are expensive and will require more than a decade to complete. However, NASA studies, as well as those of a number of other organizations, indicate that the use of nuclear systems is essential to the conduct of many important missions.

NASA has initiated enabling technology programs in cooperation with DOE and DOD which will establish the technology base for the development of flight systems for future missions as the specific operational requirements are defined. These collaborative efforts have worked well and we look forward to continued mutual technology endeavors with DOE in advanced nuclear power and propulsion systems.

Thank you, Madam Chairman. That concludes my testimony. I would be happy to answer any questions.

Mrs. LLOYD. Mr. Secretary, is it all right with you if we proceed with Mr. Aldrich. You're not on a tight schedule, then?

Mr. YOUNG. Certainly.

Mrs. LLOYD. I'm concerned about new activity in this budget requesting $30 million for the SEI, Mr. Aldrich. It seems to me that in looking at the program, it's a rather generic program. If you'd be just a little more specific about some of the concepts, the technologies, and why this effort should be funded by DOE. This is not very clear to me.

Mr. ALDRICH. We have a long standing policy of joint funding on nuclear projects between NASA and DOE and also DOD.

Mrs. LLOYD. I understand that we do have a budget for the Space Nuclear Program, with NASA SDIO, but this seems to be a lot from this committee.

Mr. ALDRICH. Yes. Where we are today in the Space Exploration Initiative is pursuing the President's proposals for return to the moon and going on to Mars. In viewing this as a program over the next several years, reviewing a number of architectures for such missions, and also pursuing the most critical technologies that would support them, in the areas of nuclear power and nuclear propulsion, these are probably the most important and most long lead-time technologies we envision to be needed 15 to 20 years from now to execute these missions. We see the need to start now if we are going to achieve those kind of systems in the time frame they will be needed. Therefore, they reach the very highest priority in our funding, even in years of modest overall funding for the SEI initiative, as we begin this build-up.

Mrs. LLOYD. I'd like to ask you about the Augustine Report. Based on the recommendations of this report, will there be any major changes for the space nuclear power requirements in our future missions? Is there going to be a change in the priorities?

Mr. ALDRICH. The Augustine Committee, as had each of the committees that has reviewed potential plans for these missions, has strongly endorsed nuclear systems, power and propulsion as vital to be able to accomplish them in the manner that they are envisioned. General Tom Stafford's Synthesis Group is about to report back to Admiral Truly and then to the Space Council on their studies in the April time frame. We believe they will also strongly endorse these systems. The plan following that has been expressed by the Space Council is to pursue the recommended Stafford architectures for several years of study and, in parallel, start the up-front work on the most critical technologies, of which we see these several being at the top of the list.

Mrs. LLOYD. I want to ask you about the SP–100 program. What would be the implications if this work is not continued?

Mr. ALDRICH. If we were not to continue the SP–100 program, there would be great limitations on potential lunar base systems and, certainly, extensive restrictions on the kind of missions we could do at interplanetary ranges because of the distance from the sun and the reductions in solar capacity. At the moon——

Mrs. LLOYD. This wouldn't be a reality, would it? The kind of explorations——

Mr. ALDRICH. Some types of missions could be a reality, to Mars and beyond, but they would be greatly restricted. Whether they could be human missions would be subject to significant questions. At the moon, we could do Apollo-class missions where we stay for a short time and come back. To stay over the lunar night, and to do large base operations and do things with the materials and the resources on the moon—again large amounts of power that are required in solar systems just don't measure up to the requirements that we would have.

Mrs. **Lloyd**. I think we're going to have to look ahead. As I mentioned, we are looking at a multi-year authorization. This committee would appreciate it if you would give us a better definition of the long range funding requested that you anticipated. This will really interplay with the Tri-Agency Agreement.

Mr. **Aldrich**. We have a long-term plan with Tri-Agency and I would be happy to be sure that we've properly informed you of that. I was going to say when I mentioned our joint agreement that our current traditional plan has been roughly a third share by DOD and by NASA and by DOE as the strong technology organization with the capability of doing most of the development work. That's the basis for Memorandums of Agreement that we signed on space exploration with DOE last summer, and have in final form with DOD at the current time.

Mrs. **Lloyd**. We will be back in touch with you for a better understanding of these programs. Mr. Morrison.

Mr. **Morrison**. Thank you. Mr. Aldrich, I want to follow through in the same area. Is this year's budget in line with the Memorandum of Understanding between the three agencies on SP-100?

Mr. **Aldrich**. Yes, I believe it is.

Mr. **Morrison**. So, we are tracking and you're on a team to review that particular activity. Are we now fairly well fixed on schedule for things like the ground engineering test, for that to proceed?

Mr. **Aldrich**. We have recently reassessed the schedule and program emphasis and flow of the SP-100 at the Steering Committee which Bill Young chairs. We are each a party to readjustments in both the schedule and the sequencing of the different activities. NASA strongly believes that the new program as scheduled is appropriate based on the funding profiles we have been achieving and we see in the near future. I think it's a very supportive program. Therefore, these tests are on schedule, but they are readjusted from perhaps the schedule that might have been discussed in past years.

Mr. **Morrison**. We have to count on you gentlemen to make sure that what we are doing now in the research and development area matches your needs out there for the missions that are on the drawing board. You can guarantee us that that's in line?

Mr. **Aldrich**. Yes.

Mr. **Morrison**. I'd hate to have the R&D efforts on energy systems, for instance, end up driving the schedule for when we did certain things in space.

Mr. **Aldrich**. Today's program, as we've recently realigned it, is well linked up with the intended schedules that we see today for SEI, although I must recognize that the SEI is not yet a firmly defined program. There is going to be several years of additional study. Nevertheless, I think SP-100 both meets well the objectives and requirements, and does fit well with the intended schedules, as we would predict them today.

Mr. **Morrison**. As you sense, we are creatures of habit. Anytime we see a new category of funding, we get a little antsy. I think we will want to know everything there is to know about the Space Exploration.

Also, I wanted to ask about the RTG's. What are their futures? We noticed the department slowing down on investments in new production facilities, they say, because of a lack of orders. Do you see a continued need as far as the low energy machines are concerned?

Mr. **Aldrich**. Well, we have RTG's in flight on NASA probes today that promise to provide very important mission accomplishments. We have NASA scientific missions later in the 1990s and the CRAF and Cassini that Mr. Young mentioned, that are also important, that require these power sources. Although our mission planning and commitment beyond that is not yet specific, I believe this role in interplanetary science will continue forward from that. At some point, perhaps, SP-100 class systems will step in as they become available but, for now, there would be a continued need and requirement, I believe, for RTG systems until something later supplements them. Our space exploration, I believe, will continue forward from today's current committed plans.

Mr. **Morrison**. Thank you. Thank you, Madam Chairman.

Mrs. **Lloyd**. Thank you very much, Mr. Morrison. Mr. Schiff.

Mr. **Schiff**. Actually, I have no questions, Madam Chair. I just want to thank you for holding this committee hearing on this important subject and thank the witnesses for testifying.

Mrs. **Lloyd**. It's good to see you back, Mr. Schiff. Mr. Costello—Mr. Costello; Mr. Wolpe.

Mr. **Wolpe**. Thank you very much, Madam Chairman. Mr. Young, I'd like to just read a short paragraph from the NES, the energy statement, on page 2-50. It says, "NES R&D strategy is intended to foster a new resource oriented approach, and not merely more of the same traditional Government-funded energy R&D programs. The Federal Government has had a substantial broad-based energy R&D program since the 1973 Oil Embargo. From 1980 through 1990, the Government has invested about $21 billion in energy technology R&D. This investment has had relatively little payoff, for a combination of reasons". The second of the reasons cited here is "poor R&D choices, for example, synthetic fuels, breeder reactors".

I spent a good deal of time in the early 1980s opposing these multi-billion dollar programs, as you may be aware. My primary objection was that these high cost programs sought to develop technologies which were incapable, in fact, of competing in the marketplace, at any time in the foreseeable future. I simply don't believe the Federal Government can force technology on the marketplace. Such efforts are doomed to failure, and will only result in wasting huge sums of taxpayer dollars.

I confess that I am concerned about that same historic pattern being repeated once again in DOE's advanced reactor program. Page C-25 of the National Energy Strategy indicates that under baseline projections, it is under current policy if we did nothing new. The nation will not consume any nuclear- generated electricity after the year 2030. Essentially, the industry would be dead. That's basically what that projection of the Department of Energy indicates. Despite the expenditure of billions of dollars in federal subsidies, this technology has clearly been rejected in the marketplace.

I guess the first question that I would ask of you is whether you share the present assessment contained within this work here of the breeder program?

Mr. YOUNG. Speaking specifically of the breeder program, I think that the time frame of the need for breeders has advanced considerably into the future, so that there is not a need at the present time for contemplating breeders. We are not pursuing breeders in our programs.

Let me address nuclear power in general, relative to the comments you are making. First of all, in terms of advanced R&D, the Department of Energy has reviewed the various programs that are proceeding in nuclear power and is entirely supportive of the R&D programs presently planned. With respect to the overall projection for nuclear power use, you are citing what we call the base or no policy change case, which the Department does not at all support. It should not be construed as a projection that we are endorsing in any way. The NES, quite to the contrary, endorses, and shows the need for, a greatly expanded role for nuclear energy.

Mr. WOLPE. No, no, I didn't mean to suggest that you were endorsing that. My point is that your own projections seem to suggest that notwithstanding the very remarkable sums that have been invested in subsidizing nuclear power, that nonetheless, it has not taken in the marketplace. Therefore, absent another jump start, it is doomed to extinction. Is that not the implication?

Mr. YOUNG. I don't agree with that at all.

Mr. WOLPE. Then why are we talking about it today?

Mr. YOUNG. You raised the specific points, Congressman.

Mr. WOLPE. No, no, I didn't mean today, I meant in terms of the National Energy Policy. If, in fact, nuclear power was doing well in the marketplace, why would you be projecting its demise by the year 2030?

Mr. YOUNG. That was, as I said, not a new policy. The reason for the demise, as the NES clearly points out, is that there are obstacles in our process to nuclear power that are inappropriate and need to be corrected and removed. The focus of the NES is to identify those obstacles and to identify ways in which they can be removed and rectified so that nuclear power can again be a technology that would be utilized. From the projections of the NES, nuclear power has been treated on a economic basis. The fundamental basis for the various projections in the NES is that all technologies must compete on an economic basis. When you remove the obstacles to nuclear power, nuclear power can do that and it can be applied in the magnitude that the NES projects.

Mr. WOLPE. Can you provide the documentation to prove that?

Mr. YOUNG. Certainly we can.

Mr. WOLPE. Would you get that——

Mr. YOUNG. We have detailed analyses backing up the NES that we could provide.

Mr. WOLPE. Is it not true that this technology would have no chance to enter the commercial marketplace without Government assistance?

Mr. YOUNG. Let me take one technology at a time. Let me take the advanced light water reactor. We are putting a fairly small amount of money through the Department of Energy, on a strictly cost-sharing basis, to develop standardized, advanced, even safer designs that will be economic in the marketplace. The role that is being applied for nuclear energy, the Government cost-sharing, and contribution is no different than the Government has applied for other technologies that need support to bring them into the marketplace.

Mr. WOLPE. Again, I was just looking for a straight answer.

Mr. YOUNG. I gave you a straight answer.

Mr. WOLPE. Is it true that this technology would have no chance to enter the commercial marketplace, without Government assistance?

Mr. YOUNG. By Government assistance, yes, in terms of rectifying the licensing process and reforming it to give nuclear energy a level playing field to compete with other technologies.

Mr. WOLPE. In other words, the issue is that you could abolish the research and development component, then, and still have it enter the marketplace?

Mr. YOUNG. No, I didn't say that.

Mr. WOLPE. You are saying now that you were referring or saying that there was a need for Government assistance only to the regulatory side of the process?

Mr. YOUNG. Two things, for the advanced light water reactor. We are building heavily upon the 30 year technology base that is there and has been operating safely and effectively. There is a minimum amount of money being put into standardized designs for new plants that will be even safer, and we can convey that to the public. Because of the situation in this country, the impediments to nuclear power inhibit full private sector investment. The DOE in the R&D area, is putting money into designs in a much lower level than are being put into other technologies. We also need the fix on correcting the licensing process to again give the level playing.

Mr. WOLPE. Let me just indicate that my own reservations were related to the role of Government participation in R&D efforts. I am not confident, yet, from what we are seeing in terms of the history, that the advanced reactor program is an effort to simply help a promising technology overcome minor market barriers and so can enter the commercial marketplace. I think what we've maybe seen here is technology that, in fact, without very substantial Government support, would have no chance to enter the commercial marketplace. You are referring to cost-sharing of the nuclear industry, and its willingness to engage in cost-sharing, but what indications are there that the utility industry will buy these new reactors?

Mr. YOUNG. We have very clear indications that the industry would buy them. The new reactors are being designed to a set of standards that the electric utility industry has itself established; standards for safety, standards for reliability and availability, and standards for economics. Those plants are being designed, too, and we'll meet those standards. We have every expectation and indication of interest. The industry just came out with a strategic plan for nuclear energy that clearly demonstrates their interest.

Mr. **Wolpe**. My last question is, what assurances can you give the American taxpayer that this will not waste huge sums of money as did the breeder and synfuel programs? What's the difference this time around.

Mr. **Young**. The NES clearly shows an urgent need for nuclear power, as well as other technologies, to support the electricity and economic growth in this country. The projections we have show that nuclear power is an economic competitor in the marketplace, if these obstacles are removed. Therefore, the investment in removing those obstacles is a sound investment for the country and the taxpayer. After the liquid metal program, I think that there has been a great deal learned through the development of that program that is now reflected in the liquid metal program that we are proceeding with. We learned some things that we wanted to continue; we learned some things that we did not want to continue. That's the nature of R&D. We believe that the advanced reactor, both the Liquid Metal Reactor and the High Temperature Gas-Cooled Reactor programs we are carrying out, will also be prudent expenditures. We believe that they have been significant to the overall nuclear power fuel cycle potentially, and we believe that they are being addressed on the basis that, in order to be successful, they must be economic in the market place. That's our criteria and we are carrying out our R&D towards that end.

Mr. **Wolpe**. Thank you very much. I look forward to receiving the documentation on these.

Mrs. **Lloyd**. I want to go back to the drawing board, at this point. We are to be questioning Mr. Aldrich so that he can leave, if any members of the panel have questions. Then we'll go back to Mr. Young. Mr. Barton.

Mr. **Barton**. Thank you, Madam Chairman, my questions are going to be for Assistant Secretary Young. Do you want me to question Mr. Young?

Mrs. **Lloyd**. Mr. Aldrich has to leave. Does any other member of the panel have a question for him? Mr. Stallings.

Mr. **Stallings**. If might, thank you, Madam Chairman. Mr. Aldrich, this is just for some clarification for my own mind. As I understand it, you are doing nuclear research in two areas for the space program; one for propulsion and the other to generate power for the labs, space stations, etc., is that correct?

Mr. **Aldrich**. The nuclear power would be for surface systems on the moon or on Mars. Also, the power systems would be very beneficial to spacecraft that go to the range of Mars in flight.

Mr. **Stallings**. Can you use the same technology for both?

Mr. **Aldrich**. Yes. They would, in our current thinking, be directly derived from the SP-100 program that we're currently working on with DOE and DOD.

Mr. **Stallings**. How far along are you in the development of that technology? Is it close to being to a point where you could actually install it in operation?

Mr. **Aldrich**. Mr. Young is probably the expert in this area because DOE has the strong technology lead in this area. But, the program has been going on for some number of years now, four or five years. We see another ten years of detailed development through certification of a flight system you would actually use in space.

Mr. STALLINGS. What role are the national laboratories playing in that research?

Mr. ALDRICH. The national laboratory structure of DOE is actively involved. I can't say that they all are, but the essential elements of the work are all done through the national laboratory structure. Again, Mr. Young could give you a more precise answer.

Mr. STALLINGS. Let me just conclude then with the statement, of course, that the Idaho National Engineering Laboratory has been involved in a variety of the projects. I am wondering if there is any of that activity going on at that particular national laboratory. I am thinking perhaps that would be more appropriately directed to Mr. Young.

Mr. ALDRICH. I believe that it is. The details, I think, Mr. Young could answer.

Mr. STALLINGS. All right, thank you, Mr. Aldrich.

Mrs. LLOYD. Mr. Cramer.

Mr. CRAMER. Madam Chairman, my question was asked and answered.

Mrs. LLOYD. Thank you very much, Mr. Aldrich. We appreciate having you with us today. We will have some questions we'll submit to you in writing for the record.

Mr. ALDRICH. Thank you very much.

Mrs. LLOYD. We'll look forward to having you back with us. Mr. Young, looking at the budget requests, there is $20 million for a program called "First of a Kind Engineering", which, I believe, is for the advanced ALWRs, if that is correct, to go beyond certification. Now, the total cost of this program, the way I understand, has not been identified by the Congress; however, some of the reactor suppliers said that this could go to about $200 million for each design. Does this mean that it is going to be anti-competitive? Should we be funding this at all? Are we going to chose only one designer? I really think that this concept needs to be clarified for the committee.

Mr. YOUNG. Yes, first of all, the concept is to build upon the design that would be certified by the Nuclear Regulatory Commission on the basis of safety. To go beyond that by doing for the first plant, the additional engineering to develop the details to standardize that design and to permit its—to compete economically in the marketplace, on a fixed price basis, and to give you confidence on the schedules that that plant could be built upon, which is critical to the success of these advance plants. We contemplate that there are estimates that the first-of-a-kind engineering for a given design might be as much as $200 million, depending on the plant. It also, we believe, could be significantly less than that.

Our concept is one where the Government would share in the cost of this on a 50 percent or less basis. So whatever the value of the effort, the Government investment would be less than 50 percent of that. Further, we expect to go out with an RFP to get competitive proposals. We would expect in addition to that cost-sharing feature to look towards further cost recovery features from future revenue, something like that, to recover the Government's investment.

Our aim here is to go to the marketplace and let the marketplace make a decision on what technologies it supports. By marketplace, I mean the utility industry. Our specific purpose of this program is to focus attention on the need for further private sector investment in bringing these first time designs along to the point where they could be standardized. There have been no decisions made as to the number of designs that would be supported in this. Our intention is to, as I said, go to the marketplace on the basis of free market selection to see what the marketplace tells us about interest in various designs for the near future.

A principal measure of that interest would be the willingness to put private sector funding, specifically utility industry funding into a design. Again, we have not made any predetermined decisions. It's possible if more design were to be supported and the market had an interest.

Mrs. LLOYD. Do you not feel this is anti-competitive?

Mr. YOUNG. Our job is try to get the private sector to come in and commercialize this technology.

Mrs. LLOYD. This is one I would like to pursue a little bit further with you when we have just a little bit more time. I want to move on, since my time is limited. What's the current schedule for MHTGR certification?

Mr. YOUNG. Our present planning would utilize first of all, the MHTGR requires a technological demonstration. Our current planning is to work as closely as we can with the MHTGR program in the hope that that program can serve as the technological demonstration for the MHTGR. If that is the case, by about the year 2000, then a segment of the NPR and MHTGR could start operation to show the technology demonstration. We would shortly after that be able to go forward, based on some experience, with a commercial design.

Let me stress that the design that we would offer for the commercial sector must differ in certain important respects from the NPR in order to be economically attractive in the marketplace. So, as soon after the demonstration as we can, we would go to the NRC with the applicant and go through the process of getting a certification. My bottom line would be that that time frame might be something by 2005.

Mrs. LLOYD. One quick question, turning to the SP-100 space reactor program, we've appropriated about $31 million in our energy and water bill for 1991. My understanding is that DOE has only obligated about 80 percent of this funding to the labs and the contractors, which means that they've taken a 20 percent cut. Would you explain for us the lack of funds, as were directed by the Congress? This was a cut of 20 percent for the labs and the contractors.

Mr. YOUNG. Typically, Madam Chairman, we do not assign out all the funds at the beginning of the year. We sign out portions and then we follow-up during the year to pass on the additional amounts. I would have to check on that.

Mrs. LLOYD. So you do intend to see that the 20 percent is allocated to the labs and contractors?

Mr. YOUNG. Yes. We have no intention of not expending the appropriated funds.

Mrs. LLOYD. Thank you very much. Mr. Morrison.

Mr. MORRISON. Bill, let me take my couple of minutes with you and maybe go back to some basics. I think there is some confusion, even here on the subcommittee, as it relates to the role that the department has played and now anticipates playing in the future on the development of various elements within the nuclear power option. Even in the structure of the panels in front of us, we start with light water reactors. These are just new generation, to get ready for orders that we anticipate will be coming in the mid-1990s, as America looks to additional energy sources. Your investment in those new generation light water reactors is very limited, as I understand it?

Mr. YOUNG. Yes, it is.

Mr. MORRISON. That's because the technology is fundamentally there, and the National Energy Strategy defined two areas that provided specific barriers. One is the waste issue, which sort of struggles. The other is the licensing process. Your investment is to help those companies that have designs that fit in this category to work with the Nuclear Regulatory Commission for standardization of designs and preapproval of those designs. Is that accurate?

Mr. YOUNG. Yes, it is. I would stress here that for nuclear, we are investing. Let me highlight two points. One, we are investing only in the designs of light water reactors to get these designs to a point where the commercial private sector could pick up on and build these plants strictly on a commercial basis. This is in contrast to many other technologies that we are investing in the hardware and sharing the cost of demonstration. The reason for this is, as I said, that there is a very high risk perception in nuclear power. In order to make that technology available again for the marketplace, the Government must do some modest sharing of risk at the front end here to make the technology available.

Mr. MORRISON. Then if we move on, excuse me, what would you anticipate that these new generation light water reactors—they would fill needs until we got, what, into the early part of the next century?

Mr. YOUNG. We envision the advanced light water reactor being built for the foreseeable future. Our projections in the National Energy Strategy went out for 40 years, through the year 2030. Our projections at that time of the amount of nuclear power used would be principally advanced light water reactors.

Mr. MORRISON. Then the next generation of advanced reactors, gas cooled, liquid metal—you're making a greater investment in that research because, again, they are farther removed from the commercial potential, just as we are making investments in—well, yesterday's hearing was on fuel cells and coal and a host of other things, where we are making a dramatic investment. Are we being consistent in the nuclear option, as far as our distance commercialization as the driving force on federal investments?

Mr. YOUNG. I think that, I mean, our approach is where there is a commercial technology base, the Government has a minimal role of risk reduction. Where there is a new technology that, in our judgment, will benefit the Nation in the long term, but the private sector is not in a position to have the basis or be willing to take the risk to proceed with that, the Government in that long term interest does investment in the R&D. If you take the MHTGR and the ALMR technologies, each of them has specific potential role that we see.

We are, on the HTGR—it's an alternative concept with enhanced safety features, that we believe could complement the use of the light water reactor. There we are trying to minimize the cost of the Government of demonstration which is required for a new technology.

In the case of the advanced liquid metal reactor, we don't see that being deployed until sometime after the year 2010. Nevertheless, we believe the R&D is justified at this time, because the program has potential benefits to the nuclear waste solution, as well as, in a longer term, addressing the uranium resource problem. Our target on the advanced liquid metal reactor, is to prove the feasibility of the ALMR, IFR fuel cycle, and the feasibility of light water reactor fuels recycling by 1995. That's our target.

We think that in the interest of an overall nuclear power program, achieving those answers by 1995 will contribute to the climate of interest in nuclear power. Beyond that, we would be looking for the most cost-effective ways to achieve demonstration, but that hasn't really been laid out yet.

Mr. **Morrison**. I wish we had more time, because I'd like to pursue that. I just have to ask you one additional question. In our efforts to market FFTF to a variety of customers around the world, you are going to be part of a very important aspect of that. In April, you are addressing the Atomic Industrial Forum in Tokyo, as I understand it. I just would like to have on the record at this early stage, an enthusiastic response from you on whether you will help us in that marketing effort in that particular visit?

Mr. **Young**. Yes, I certainly will. I think, as I said, we've been doing that so far. I would expect to continue that support for the initiative. We've always said that it was with extreme reluctance that we had to make a decision on potential shut-down. We strongly support any efforts that will permit that facility to keep going.

Mr. **Morrison**. We thank you for Tom Hendrickson, who was part of the FFTF team and the role that he played in a recent visit. Thank you, Madam Chairman.

Mrs. **Lloyd**. Thank you, Mr. Morrison. You are not going to accompany Mr. Young?

Mr. **Morrison**. Maybe the subcommittee could go along.

Mrs. **Lloyd**. I don't think that is a bad idea. Mr. Barton.

Mr. **Barton**. Thank you, Madam Chairman. Mr. Secretary, I read your formal testimony in its entirety. I want to complement you on the depth that you put into it. One of the items that you mentioned that you didn't mention in your verbal remarks is a new program for nuclear engineering scholarships. Could you elaborate a little bit on that? Is that undergraduate, graduate, and what, if any, guidelines have you developed yet on that?

Mr. **Young**. Well, we're still in the process of developing the program. Basically, it would start in Fiscal Year 1992, with $2.5 million. It would be both undergraduate and graduate, would be my expectation.

Mr. BARTON. Okay, but really it's just now an idea; it hasn't been fleshed out, is that correct?

Mr. YOUNG. What we're trying to do—we've been all along doing some work with fellowships in nuclear engineering. What we're trying to do is to gather all those elements together, expand upon them, and apply more money to the effort to support nuclear engineering.

Mr. BARTON. We have an excellent nuclear engineering program at a school called Texas A&M University that's in my district. At the appropriate time, I will be happy to give some guidance on how to set up that particular program.

[Laughter.]

Mr. YOUNG. We look forward to your input.

Mr. BARTON. I'd like to go to the National Energy Strategy. Congressman Clement and myself last week introduced a comprehensive Licensing Reform Bill for nuclear energy. I would commend that to your attention. Certainly, I know that the legislation would comply with several components of the strategy that Secretary Watkins and yourself have put forward. With regard to some of the questions about nuclear power, if, in fact, we're successful in implementing that part of the strategy, with regards to the nuclear option, do you have an idea of what percentage of the electrical generation needs that nuclear power could provide in the year 2010, or in the early 21st century? I think we're approximately around 15 percent, somewhere between 12 percent and 15 percent.

Mr. YOUNG. Excuse me, just a moment. Yes, about 15 percent is the answer. Because of the hiatus in orders for new nuclear plants, and the lead time to get them on here, we do expect to have new nuclear plants starting to come on in the first decade of the next century, initially at a slow rate, recognizing the situation in the Nation. However, that percentage would grow during the next century, to something in excess of 20 percent. We foresee the longer term role for nuclear power to be even a higher percentage of the electricity generated than is being generated today.

Mr. BARTON. I want to tail-in on a question that Congressman Wolpe asked about the viability of the nuclear option in the marketplace. I think he makes an excellent point that it has got to, at some point in time, be competitive; vis-a-vis, gas-fired turbines, oil-fired turbines, or coal-fired generating capacity. If we are successful in licensing and reforming the licensing process and if, in fact, some of these second generation reactors are commercially built, how would their kilowatt per hour costs compare to current non-nuclear kilowatt per hour costs? Are we going to be competitive?

Mr. YOUNG. Yes, sir, the electric utility industry has established requirements for the economics that nuclear power plants must achieve if they are to be of interest to the utility industry, and to be competitive with other alternative forms of generation. The modeling that was done for the NES took each technology and established what economics could be expected for that technology. Then the runs were made and the technologies were—the amount of the technology used was chosen based on economics, so that the amount of nuclear energy used that you see in the NES and those charts, that stems from nuclear competing against other alternative technologies, considering factors such as baseload. I mean, there is a difference between baseload technologies and peaking technologies; so there were factors like that taken into consideration. The fundamental factor was economics, and the fundamental aim of the design programs that are going on right now for the advanced light water reactor is that they must meet these economic projections.

Mr. BARTON. Are we in a range from, say, seven to ten cents per kilowatt hour, just in general?

Mr. YOUNG. I'd have to—I mean, it depends on what year's dollars you are assuming, etc. I can't really give you a number at this point. I can send you something, if you'd like.

Mr. BARTON. I mean, it's not twenty cents or thirty cents. I mean, it's competitive in the industry.

Mr. YOUNG. It depends on what year. If you're talking 2030, it's a different matter than talking today. I would say that nuclear power will be competitive with other competing technologies, such as clean coal, renewable energy, natural gas, etc. I can give you some figures.

Mr. BARTON. In order for it to be commercially viable, we can't invest the kind of money that Congressman Wolpe is concerned about and then put it in the marketplace and have it, in today's dollars, twenty cents a kilowatt hour, for example. Nobody will buy one. So I think he makes an excellent point. You know, I disagree with him in that we shouldn't be doing it. I think we should. I think it can be competitive, but we certainly have got to make sure that in working with our commercial partners, we come up with designs that once we've certified the safety and the viability, they generate electricity in a way that the marketplace will buy at a competitive price. One final question, Madam Chairman.

Mr. YOUNG. May I just say, again, we have very specific targets that we know must be met to be competitive. We are on track to meet those targets. We are putting a minimum investment in standardized plans, which is crucial to being able to meet those targets. We are saying to the marketplace, once the standardized design is developed, you're on your own, guys. It's going to compete freely in the marketplace. We believe it can, but it will be competing on that basis.

Mr. BARTON. Okay, one final question on these advanced designs. What interchanges are being done with the French and Japanese to make sure that we are state of the art and don't invest so much in a particular design that by the time it gets to the marketplace, our international competitors are one step beyond this, and what we've done is no longer competitive?

Mr. YOUNG. I think in the advanced light water reactor programs, you would see that there is much international participation in those program in the various technologies. There is an active effort to learn from the experiences in the other countries and make input.

Mr. BARTON. Thank you, Madam Chairman.

Mrs. LLOYD. Thank you very much, Mr. Barton. Mr. Stallings.

Mr. STALLINGS. Thank you, Madam Chairman. Mr. Young, I appreciate this opportunity to visit with you on this budget proposal. In reviewing your testimony and the documents, it looks to me like DOE has requested $49.5 million for the advanced reactor R&D

program. Could you comment on the allocation of funds between the modular high temperature gas reactor and the advanced liquid metal reactor?

Mr. YOUNG. Yes. I will give you an answer here and an allocation which I can give you orally. As you know, there have been several discussions within the Administration on that allocation, which we have now resolved, but I still have to process a formal submittal through the Administration to you, so that I would say that this is an oral summary at this time. The allocation would be largely in support of the advanced liquid metal reactor; in terms of dollar level, approximately $41 million into the advanced liquid metal reactor, and $6 million into the high temperature gas cooled reactor.

The reason for that allocation is based on our assessment of the needs of the technologies, the status of the technologies, and the availability of funds and other ways to support the ongoing efforts. The $41 million for the advanced liquid metal is, I think, slightly less than would be desired to carry the program forward at full speed, but it is an amount to efficiently proceed with that technology with the aim of getting the kinds of answers I said by 1995. That is, knowing whether that technology really is feasible and whether the concept of actinide recycle is feasible as a potential contributor to the nuclear waste solution.

On the MHTGR side, we are in the process of developing that design to be economically competitive. I would say that one of the benefits that we have achieved in looking very hard at the economics of all the technologies here is that we've been able to focus on their economic competitiveness. We are in the process of improving that competitiveness for the HTGR and, therefore, the amount of money that we would be allocating to it is consistent with the kind of activities that would have to be proceeding in fiscal 1992.

Another very important factor in the selection of that breakdown is that there is a major design and development effort ongoing on the NPR-MHTGR. Again, to be most cost effective, we have taken advantage of every way we can of doing work in common with that program. In fact, in the Fiscal Year 1992 budget for the NPR-MHTGR, we have identified approximately $129 million of activities that are in the NPR budget that are common to the commercial MHTGR development process.

The NPR is in basically a lead role in terms of development to the concepts. We have as many comparable features as we can in design. About 80 percent of the design is quite the same for either the commercial plant or the NPR, so we have dovetailed ourselves with that program and are taking maximum advantage of the amount of money spent. We believe that, on balance, $135 million that is being spent on common activities or exclusively for the commercial plant is a very prudent expenditure of funds. Now, at the end of this year, the MHTGR and heavy water reactor programs will be narrowed down to one. If the MHTGR is not selected, obviously, I think we are going to have to re-look at some of the funding to make sure that the commercial MHTGR would proceed in a manner that would be effective. This is the Administration's plan at this time, to proceed in the most cost effective manner on both technologies.

Mr. STALLINGS. Since the purpose of the NPR will be primarily defense, is the Defense Department putting up any money for the research on the high temperature gas reactor, or is this all coming out of the Department of Energy funds?

Mr. YOUNG. Quite frankly, I don't know. That's not in my area. I just can't answer you as to how much of the money is DOE versus DOD.

Mr. STALLINGS. But the funds that we're seeing on this are all Department of Energy?

Mr. YOUNG. The funds that we're seeing are DOE budget.

Mr. STALLINGS. The proposed 13 percent decrease in the fiscal year 1992 advanced reactor R&D budget over the fiscal year 1991 funding level continues an accelerated trend of decreased support of advanced reactor R&D by the Department of Energy. This trend will continue to erode the expertise and infrastructure necessary to support advanced reactor R&D. How does the DOE rationalize and support the obviously negative trend in view of the NES emphasis on nuclear power?

Mr. YOUNG. The negative trend on the advanced reactor fundings? Well, I think we've looked at each technology and said, you know, what kind of activities, what kind of funding are justified at the present time. Our decisions are based on that. I think that if you look at goals here, on the ALMR, specifically, our goal is to reach an answer by 1995 on the various feasibility questions I have described. The amount of funds that we are applying are sufficient to meet that goal.

Quite frankly, we are in a very difficult budget time, as you all appear even more aware than I am. We have to exercise priorities here. The priority is the advanced light water reactor, because of its early application. The liquid metal reactor is a priority activity for the reasons I indicated, and we think it is getting sufficient funding. The MHTGR, I think, has a particular circumstance which I just described. So it's not a question of proportion of funds, it's how much is needed to carry out an effective program under the circumstances.

Mr. STALLINGS. One final question, you said you would have to rethink priorities if the heavy water reactor was selected for the NPR. What is your best guess as to the future of the high temperature gas reactor, if the heavy water reactor is selected for the NPR?

Mr. YOUNG. First of all, let me just say, I don't believe I said we had to rethink our priorities. I think I said we'd have to rethink funding situations.

Mr. STALLINGS. Fair enough.

Mr. YOUNG. I guess I, you know, I really can't speculate on what decision would be made. I think we certainly, from a commercial standpoint, see some attractive features in the MHTGR, and, on the other hand, I think, you know, because of its need for a demonstration, there is a very substantial hurdle there. We would look for any kind of demonstration, when we go to that point, to be significantly shared by the private sector. I think they are not yet willing to step up to that for, I think, good reason. So, I can't speculate on the NPR decision. I would really rate our support for the technology and stress in this budget climate the very clever thinking that would have to be derived if the NPR-MHTGR does not go forward.

Mr. STALLINGS. Thank you, Madam Chairman.

Mrs. LLOYD. Thank you very much. Mr. Wolpe, any questions for Mr. Young? You questioned Mr. Young on the first round, all right. Mr. Cramer. I am going to state that we need to abide by the five minute rule. We have nine more witnesses.

Mr. CRAMER. Madam Chairman, I have a couple of broad based questions about three budget areas that have to do with the space program. I think this gets us back to the initial questions. I would like to know more about the Space Exploration Initiative budget which, of course, last year was zeroed. This year it's at $30 million. So, if I could be submitted with that information, as well. Also, the other two categories, the SP-100 budget for fiscal year 1991 was $33.5 million, and for this year was requested at $56 million. Could you briefly tell me why the jump was there?

Mr. YOUNG. Okay, let me answer your last one first. The budget the Department requested last year was something like $51 million. That budget was passed by the House. It was cut in the Senate, and came out of conference at that lower amount. It is not an amount that we desire to really support. We had to live with it. In Fiscal Year 1992, we are submitting again the level of funding that we consider is necessary and justified for the SP-100.

As to your further question on the Space Exploration Initiative, first let me say that, you know, this funding split—basically, DOE supports the R&D on concepts and developments of technologies, and the mission agencies, user agencies, come in with the heavier funding later on when we get the specific hardware and flight qualification and mission hardware. So, we are front-end loaded in this activity by our very nature of our work. I can give you a further breakdown on the $30 million that we requested. I don't know if you want me to do it here, or if you want me to submit it.

Mr. CRAMER. I would like to have that.

Mr. YOUNG. Yes, sir.

Mr. CRAMER. Thank you.

Mrs. LLOYD. Thank you very much, Mr. Cramer.

Secretary Young, we appreciate your being with us. We appreciate your testimony. There are several items that we want to follow-up on. Again, we will be submitting questions in writing for you to answer for the record. Thank you very much for being with us today.

I would like to say to the members that because we do have nine witnesses, I would like for the members to summarize, as much as possible—the witnesses—their testimony. We will be abiding by the five minute rule.

Our next panel includes Dr. Brewer, former Assistant Secretary of Energy for Nuclear Energy, who is now President of Combustion Engineering; Mr. Nathanial Woodson, Vice President of Westinghouse; Dr. Bertram Wolfe, Vice President of Nuclear Energy, General Electric Company; and Mr. Patrick McDonald, Executive Vice President, Southern Nuclear Operating Co., Inc. Certainly, you gentlemen are no strangers to this subcommittee. It's good to see you back again today.

Shelby, I believe you are our lead witness.

STATEMENT OF DR. SHELBY T. BREWER, PRESIDENT, COMBUSTION ENGINEERING

Dr. **Brewer**. Thank you, Madam Chairman. I have a statement for the record, which I will submit. I will proceed orally very, very briefly.

Mrs. **Lloyd**. Without objection, your full statement will be made a part of the record.

Dr. **Brewer**. Madam Chairman, there are incremental signs that we may be approaching the beginning, sometime in the 1990s, the beginning of a new nuclear era. That is, the addition of more nuclear generating capacity in the United States. Your leadership and that of this committee are to be thanked and congratulated for sustaining the political support for nuclear power over the past one and one half decades of the nuclear recession.

The factors which led to the nuclear recession in the mid-1970s did not result from a pervasive deficiency in the technology. They were, instead, institutional, political, financial, and regulatory in character—a very heterogeneous population of reactor designs, custom designed, and, therefore, custom regulated; a chaotic regulatory environment, both in the NRC, AEC regulatory function, and state rate regulation—economic regulation. The utilities had, in addition, over-ordered. There were more plants on order than were ultimately needed by the electrical demand that resulted in the mid and late 1970s. To cap everything off, there was fall off in public and political support for nuclear power.

In the past two years or so, these factors have abated somewhat. Public acceptance and political support has improved marginally, incrementally. There is a new stress on standardization in the industry and with the Nuclear Regulatory Commission. Licensing reform, pre-licensing of standardized designs has been instituted by rule making. The need for new capacity is indeed seen in the 1990s.

While many of these barriers are still with us, the trend line, however, is encouraging. There is a gentle encouraging wind at our backs, so to speak. I believe we should continue to concentrate on fundamental institutional issues to refrain from a call to arms to invest in a totally new reactor technology and drop the evolution of technology that we have built 30 years of very successful experience on.

As you weigh choices, Madam Chairman, among the DOE-sponsored programs, I would ask that the committee not ignore the certification programs for the two evolutionary ALWR designs; the General Electric ABWR and my system, 80 Plus Combustion Engineering Design. You may overlook it, because federal funding requirements for these two programs are so small that they don't generate a large constituency.

I am convinced now, more than ever, that the evolutionary ALWRs will be the only advanced reactors pre-licensed and available for use by the utilities during the 1990s. Thank you, Madam Chairman.

[The prepared statement of Dr. Brewer follows:]

STATEMENT SUBMITTED TO
SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT
OF THE HOUSE OF REPRESENTATIVES COMMITTEE
ON SCIENCE, SPACE AND TECHNOLOGY

FY 1992 DEPARTMENT OF ENERGY
NUCLEAR RESEARCH AND DEVELOPMENT PROGRAMS

Shelby T. Brewer
President, ABB Combustion Engineering
Nuclear Power

March 6, 1991

Thank you, Madam Chairman, for the opportunity to provide testimony to this Committee, as it considers the Department of Energy (DOE) budget for Fiscal Year 1992.

I am Shelby T. Brewer, President of ABB Combustion Engineering Nuclear Power.

AN EVENTFUL YEAR

The year that has passed since we last gathered to discuss the FY-91 budget has been a very eventful one.

Madam Chairman, you and other members of this Committee demonstrated true leadership by introducing advanced reactor legislation last year. I encourage you to continue your efforts in the current session of Congress.

Also, during last year, the lead nuclear industry organization NPOC (Nuclear Power Oversight Committee) issued its Strategic Plan for Building New Nuclear Power Plants. The Strategic Plan marks a major milestone in the revitalization of the nuclear option here in the United States. Over the past year, we have seen a clear up-swing in utility interest in re-examining nuclear's viability as a source of electrical generation. More recently, the Department of Energy has just released its National Energy Strategy -- which includes an important role for nuclear power.

As if to underscore the importance of establishing a sound and reasoned approach to energy production and use, the recent crisis in the Gulf adds a sense of urgency to our efforts. This is clearly the time for our nation to establish an energy program and to begin its implementation. I have no doubt that this Committee will play a major role in charting the nation's course.

The past year has been an eventful one for ABB Combustion Engineering, as well. Last October, Congress approved the reprogramming of funds to continue support of our System 80+ Design Certification Program. We are currently negotiating the contract changes with the Department of Energy and we hope to have the contract in place by September. I want to personally thank you, Madam Chairman, and the other members of this Committee, for your support of the reprogramming request.

We are making good progress in preparing material for submittal to the Nuclear Regulatory Commission. In fact, the last of our major submittals for the safety analysis report was just sent to the NRC. It was over three thousand pages long. We are hopeful that the NRC will proceed expeditiously with the review of our application, now that various policy issues related to the design certification process have been resolved.

During 1990, ABB Combustion Engineering was also a member of both winning teams for the two New Production Reactors -- one based on HTGR technology and the other based upon heavy water technology. We also saw the start of construction on two new System 80 reactors. They are the first two System 80 reactors to be built in the Republic of Korea and will form the basis of future baseload nuclear capacity there. We are currently negotiating a contract for the next two units.

KEEPING THE FOCUS ON INSTITUTIONAL ISSUES

In my testimony to this Committee last year, I stated that the first nuclear era in the United States was brought to a halt because of several negative institutional factors -- decreasing growth in electrical demand, high interest rates, unpredictable licensing by federal authorities, a lack of standardization, unfavorable rate regulation by state authorities, and a loss of support by the public. There were no inherent or pervasive deficiencies in the technology.

What I said last year still holds true. If we are to restore nuclear energy as a viable option for America's future, we must first tackle the institutional obstacles that stand in the way. My views are supported by the NPOC Strategic Plan, which I mentioned earlier. This document presents the nuclear industry's collective wisdom on what actions are needed to restore the nuclear option by the turn of the century. It's fourteen building blocks address institutional issues: standardization, licensing reform, ownership & financing arrangements, siting, waste disposal, and public acceptance. The Plan does not call for any new technological magic bullet to further deploy nuclear power in the U.S.

The issue that demands our most urgent attention is the Design Certification of standardized Advanced Light Water Reactors -- e.g, ABB Combustion Engineering's System 80+ and General Electric's ABWR. The lead time for obtaining certification is proving to be very long and it will be on the critical path for any utility decision to order a new nuclear plant.

ABB Combustion Engineering began submitting System 80+ documents for NRC certification review in 1987. We have experienced numerous delays and procrastinations in the review process. We now expect to be told that Design Certification will be achieved in 1993 (although we believe that it could be achieved earlier). The total review period will span almost seven years. Although they are slightly ahead of us in the review process, General Electric has experienced the same delays in its ABWR review.

This also does not bode well for the other advanced designs. We must demonstrate successful resolution of institutional issues on the evolutionary ALWRs, as a necessary first step. Evolutionary designs are based upon proven technology and fit comfortably within the NRC's current regulatory regime. If we are not successful here, then we have little hope of success for the smaller, passive reactor designs that will require the NRC to make difficult and time-consuming technical decisions. I am convinced, now more than ever, that the evolutionary ALWR's, e.g., our System 80+, will be the only advanced reactor technology licensed and available for use by utilities during the 1990's.

THE ALWR BUDGET FOR FY-92

ABB Combustion Engineering is supportive of the Department's FY-92 budget request for ALWR programs. For the reasons that I've already stated, the federal government's commitment to ALWR R&D should receive increased priority during the next several years.

The budget request includes $20 million to begin a new program for First-Of-A-Kind (FOAK) Engineering for ALWRs. FOAK Engineering, in this instance, is defined as the non-recurring engineering effort to produce a detailed standard design -- beyond the level-of-detail that is required at the time the design is certified by NRC. It stops short of design details that are specific to a particular site or unit. ABB Combustion Engineering and the other reactor manufacturers have indicated that it could cost $200 million or more to perform all of the FOAK Engineering effort for each standard design. Even in a cost-sharing arrangement, DOE's new program will likely become the largest single activity within the ALWR line item.

In approving this new program, Congress must assure that sufficient funding is available to support FOAK Engineering efforts by all three of the reactor suppliers. The worst scenario would be for only one supplier's program to be funded. That supplier would then have essentially complete control of the commercial market for the next generation of nuclear power plants. This would be an extremely unfair competitive advantage that would violate the principals of our free-market economy. DOE should not be forced to down-select to a single, national ALWR design because of insufficient funding. U.S. utilities do not want a situation were there is only one option. They are not prepared to make such a choice. Utility executives have told me that they are unable and unwilling to pick a single design for the future.

I agree with the view stated in the NPOC Strategic Plan that the FOAK Engineering effort for a particular standard design must be synchronized with the design's certification program -- such that the FOAK detailed engineering effort does not overtake NRC review. Otherwise, NRC-mandated changes could result in a need to re-perform the FOAK engineering work, at considerable added costs.

Most importantly, however, we should assure that sufficient funds will be available to complete the Design Certification Programs that are currently under way. Much of the past year was devoted to the question of just what level-of-detail would be required by NRC. Although the Commission has just issued guidance to the Staff on this issue, we will not know the actual impact until the Staff has completed its review of the System 80+ and ABWR applications.

If Congress were faced with a question of priorities, we would strongly urge you to select Design Certification as the top priority. Regulatory stability is the greatest single obstacle to restoring the nuclear option. If we can demonstrate that the institutional obstacles can be overcome and, therefore, that nuclear energy is a sound investment, the vendors and the utilities will then be ready to invest in the engineering efforts necessary to implement the nuclear option.

SUMMARY

The past year has seen a number of significant events in our efforts to restore the nuclear option in the U.S. Government and industry must continue to work together, to assure that the institutional problems, which ended the first nuclear era, do not prevent the beginning of a second era. I believe that the evolutionary ALWRs, e.g., System 80+ and ABWR, represent the only nuclear technology that will be available before the end of the century to meet our nation's energy needs. Continuing to support Design Certification of these designs (and the regulatory stability that will be achieved) is the single most important action that this Committee can undertake. This path also represents the least dependence on federal funding.

Thank you, Madam Chairman, for the opportunity to appear before this Committee. I'm sure that you will do what is in the nation's best interest.

Mrs. LLOYD. Thank you, Dr. Brewer.

Mr. Woodson, please proceed.

STATEMENT OF NATHANIAL D. WOODSON, VICE PRESIDENT AND GENERAL MANAGER, WESTINGHOUSE ELECTRIC CORP.

Mr. WOODSON. Madam Chairman and members of the committee, good morning. I am Nat Woodson. I'm Vice President and General Manager of the energy systems business unit of the Westinghouse Electric Corporation. I am the corporate officer responsible for managing our firm's nuclear power activities.

There is no question that significant progress is being made toward renewing the nuclear option in the United States. We applaud the Department of Energy's long and vigorous efforts to develop a National Energy Strategy. We believe the results are significant. We strongly support the initiatives on standard plant designs, licensing reform, and accelerated advanced program funding. These initiatives recognize the importance of nuclear power and a balanced energy plan.

That importance is further recognized in the Nuclear Power Oversight Committee's strategic plan for new nuclear plant construction. We, at Westinghouse, believe that all of these initiatives are important to the future of nuclear power in the United States.

Both the NPOC plan and the Department of Energy funding requests focus priority on timely actions that will enable new plant orders to be placed by 1995. We strongly endorse this approach. Clearly, continuous program funding is vital. Of equal importance, are timely decisions and actions on all elements of the strategic plan for new plants. We have made progress, and we cannot afford to have that progress slowed by missed milestones.

I believe that reactor suppliers must change, just as we support changes in other institutions. At Westinghouse, we intend to do our part, working together with our project partners, Congress, the Department of Energy, the Nuclear Regulatory Commission, and the utility industry to have new nuclear plants producing power by the turn of this century.

As you know, we are working on a new plant design, the AP-600. It is our Department of Energy/Electric Power Research Institute's sponsored design for advanced passive 600 megawatt plants. The highly simplified design, based on the successful Westinghouse pressurized reactor technology, saves both material and space. The naturally safe plant relies on the forces of nature to produce enhanced safety, while significantly reducing the amount of safety-related equipment. Modular construction will reduce building time, as well as costs.

We are making great progress on the AP-600. With 100 percent of the conceptual effort complete, the design is in full conformance with the current Nuclear Regulatory Commission and utility requirements for advanced, naturally safe reactors. The Standard Safety Analysis Report is scheduled for completion by mid-1992, and final design approval by the Nuclear Regulatory Commission staff is expected at the end of 1993. By December, 1994, the AP-600 will receive design certification. The Westinghouse AP-600 will be the first simplified, naturally safe plant submitted to the Nuclear Regulatory Commission for certification under 10 CFR 52.

Our Lead Plant Strategy Program calls for activities such as site certification and first-of-a-kind engineering, to be undertaken in parallel. We believe this approach will enable us to bring the first AP–600 to commercial operation by the end of the decade.

Let me now focus on the Department of Energy funding request for fiscal year 1992. My written testimony provides detailed comments in all areas. I'll briefly mention and discuss first-of-a-kind engineering in some greater depth.

First, Westinghouse strongly supports the Department of Energy's priority attention to the advanced light water reactor program. The increased funding to achieve timely certification of designs will ensure that a new plant design is market-ready in time to meet the demand for new base load capacity.

Second, predictable licensing and stable regulation are needed to reduce the financial risks associated with new nuclear plant construction and operation, and to enhance the public's ability to address valid safety questions early in the licensing process. We would welcome legislative action that clarifies the Nuclear Regulatory Commission's authority to limit the scope of a second hearing to conformance issues and to allow the commission to take such a hearing off the critical path, without compromising opportunities for meaningful public participation.

Finally, first-of-a-kind engineering for advanced reactor designs will play a major role in the new reactor industry. It provides the certainty required by the utility industry before committing to new orders, and it is critical to achieving industry goals of standardization.

Cost and schedule assurance is a top priority, and a prerequisite for new plant construction. Through first-of-a-kind engineering, all non-reoccurring, first-time engineering will be completed up-front, opening the door to firm price and schedule offerings.

Let me restate that in more practical terms. When first-of-a-kind engineering is completed, Westinghouse and its partners could offer a turnkey proposal for the AP–600 that guarantees project costs, completion date, and performance.

Also, first-of-a-kind engineering so completely defines plant details that only equipment procurement and site specific design work remains. Thus, first-of-a-kind engineering, coupled with design certification, results in a standardized design. To assure utilities are provided with a continuing renewed nuclear option, by the mid-1990s, first-of-a-kind engineering must be initiated in 1991. We fully support the Department of Energy initiative for a cost-shared program on first-of-a-kind engineering. We urge Congress to approve the $20 million budgeted for this program in fiscal year 1992.

The facts are plain. Significant progress is being made toward renewing the nuclear option. The National Energy Strategy sets a positive framework. The Department of Energy, the Electric Power Research Institute, and the industry are rapidly advancing the technology through continue strong support from Congress. The Nuclear Power Oversight Committee has developed a solid plan, whose goals can be achieved through cooperation and collective, timely action.

The promise of reliable, low-cost, environmentally sound generation of electricity from nuclear power is valid and it is viable. Working together, we can fulfil that promise. I thank you for giving me the opportunity to address your subcommittee.

[The prepared statement of Mr. Woodson follows:]

Testimony by

NATHANIEL D. WOODSON
Vice President and General Manager
Energy Systems Business Unit
Westinghouse Electric Corporation

before the

United States House of Representatives
Committee on Science, Space, and Technology
Subcommittee on Energy

March 6, 1991
Washington, D.C.

NATHANIEL D. WOODSON

Vice President and General Manager
Energy Systems Business Unit
Westinghouse Electric Corporation

Nat Woodson is vice president and general manager of the energy systems business unit of the Westinghouse Electric Corporation. Appointed to this position in November 1990, he is responsible for the firm's commercial nuclear power generation activities.

Mr. Woodson joined Westinghouse in 1966 as a systems engineer with the atomic power division. Following a series of key project management positions in nuclear energy systems, he was named vice president of projects for Westinghouse Nuclear Europe in 1975.

In 1977 he was named president of Westinghouse Nuclear Espanola in Madrid, Spain, and in 1981 became general manager of Westinghouse Nuclear International, headquartered in Pittsburgh, Pennsylvania. In 1982 he was appointed general manager of the Westinghouse nuclear operations division.

Mr. Woodson became general manager of the Westinghouse energy systems technology divisions in 1986, and in May 1988 was appointed general manager of the nuclear fuel business unit in Monroeville, Pennsylvania. He was named President, International in March 1989 and in the same month was elected a Vice President of the corporation.

A 1963 graduate of Yale University with a B.S. in mechanical engineering, Mr. Woodson also holds a masters degree in nuclear engineering from the Massachusetts Institute of Technology and an M.B.A. from the University of Pittsburgh. In 1980, Mr. Woodson completed the Advanced Management Program at the Harvard University School of Business.

CHAIRMAN LLOYD AND MEMBERS OF THE COMMITTEE:

Good morning, and thank-you for giving me this opportunity to meet with you today to discuss the Department of Energy's (DOE) nuclear-related funding needs for fiscal year 1992.

I'm Nat Woodson. As vice president and general manager of the energy systems business unit of the Westinghouse Electric Corporation, I am responsible for managing the firm's commercial nuclear power activities. And I'm no stranger to the nuclear industry ... having worked in this business for all but 27 months of my 25 year career.

Since its founding in 1886, Westinghouse has been one of the world's foremost providers of electrical energy technologies. In fact, during our 105 years in business, we've supplied over 270,000 megawatts of power generating capacity in 45 countries. We pioneered nuclear energy with the design of Shippingport, America's first nuclear power plant, in 1957. Since then, more than half of the world's nuclear plants have been based on our Pressurized Water Reactor (PWR) technology.

More than 30 years ago, spurred by the "Atoms for Peace" plan, the electric utility industry embarked on the technological challenge of harnessing the atom for the generation of electric power. The visionaries that pioneered the nuclear power industry recognized the promise of reliable, low-cost power. That promise of nuclear power is one we can still fulfill. And, Westinghouse remains -- as always -- committed to doing its share.

Today, Westinghouse shares the utility focus on total quality and operating plant performance. We all understand that sustaining excellence in plant performance is the real road to reliable, cost-effective and environmentally sound electricity from the atom ... and the road to the next era of nuclear power in the United States.

Our industry focus on operations is paying off. Nuclear plant performance in the United States has improved dramatically. According to the Institute of Nuclear Power Operations (INPO), in 1989 the average U.S. nuclear plant availability factor set a record of 62.5 percent. And, radiation exposure per unit declined. What's more, this trend is continuing. In 1990, the availability factor for 51 Westinghouse plants was 74.3. This is a positive sign.

And there are other positive signs. We applaud the DOE's long and rigorous efforts to develop a National Energy Strategy. The results are significant. As President Bush stated, "...it is a strategy for an energy future that is secure, efficient and environmentally sound." And, we strongly support initiatives on standard plant designs, licensing reform, and accelerated advanced reactor funding. These initiatives recognize the importance of nuclear power in a balanced energy plan.

Nuclear power's importance to our nation's energy future is further recognized in the Nuclear Power Oversight Committee's (NPOC) strategic plan for new nuclear plant construction. We at Westinghouse believe that all these initiatives are important to renewing the promise of nuclear power.

Nuclear Power's Role in Our Energy Future

Our National Energy Strategy enables us to establish an energy base that's optimal from economic, security and environmental perspectives. Electricity from nuclear power -- an energy source which is efficient, cost-effective and environmentally clean -- has an important role to play in this energy future.

As an energy form electricity is extremely flexible ... generated from many sources ... easily adaptable to user requirements ... and in many cases a direct substitute for oil. And, it fuels many common but critical components of modern life.

In this country, electricity demand generally grows at about the same pace as the economy. But throughout much of the 1980s, actual electricity demand outpaced forecasted demand by 1.5 percent per year, on average. Should this situation continue, in just a few years capacity margins could drop below the levels generally recognized as acceptable. Such an event would increase the likelihood of reliability concerns in many regions.

At 2.6 percent per year growth, DOE forecasts that more than 126 thousand megawatts of new capacity will be needed to meet the electricity requirements of 2000. Utilities throughout the country are evaluating alternatives for installing new capacity. But many are wary of being left with excess capacity should demand slow, and so are reluctant to consider building large central station power plants. Today, gas-fired combustion turbines and combined cycle plants are being used to satisfy peaking, intermediate, and in some cases baseload capacity needs.

But by the late 1990s, substantial investment in new baseload power generation will be required. Nuclear power can provide a prominent source of this baseload power. Plant life extension programs will enhance the service availability of current facilities and plant operators will strive to continue to enhance plant safety and reliability. And, new designs will provide simpler, safer and more reliable next-generation technologies.

Industry Responses: Renewing the Nuclear Option

Today the industry remains committed to moving forward with the nuclear option. We're completing the current generation of reactors and intensifying our research and development efforts in order to hasten the commercialization of new designs.

I'll talk more about these concepts later. But for now, let me stress that costs for these engineering efforts must be borne by a broad portion of the industry -- including the federal government.

AP600 Update

Westinghouse believes in the future of nuclear power. We're actively and aggressively pursuing a renewed nuclear option through the development of simpler, more affordable reactor designs. But then, moving toward greater levels of safety, economy and reliability has always been the guiding principle behind Westinghouse technology development. Now, two major design programs have culminated in the most economical nuclear power plants available: the advanced pressurized water reactor (APWR) and our advanced, naturally-safe design, the AP600.

The APWR program involves Westinghouse and five Japanese utilities, and has produced a fully tested and validated state-of-the-art 1350 MWe plant. This design, referred to as the SP/90 (Standard Plant for the 90s) has received U.S. NRC design approval in letter form. Formal design approval is imminent.

The AP600 is our DOE/EPRI sponsored design for an advanced passive 600 MWe plant. Its smaller size allows capacity to be added in increments that match demand growth more precisely than is possible with larger facilities. The AP600 is also extremely competitive with other generating sources. Our analyses show that the overall capital cost for the plant should register at about half the cost per kilowatt of some recently constructed nuclear facilities.

These savings derive from simplification, modularization, and extensive reference plant experience. The simplified design of the AP600 saves material and space. And, safety systems which rely on natural phenomena for their operation result in massive reductions in piping, valves, cables, pumps and heat exchangers. Modular construction techniques also reduce building time and costs.

U.S. utilities are leading an industry-wide effort to establish the technical requirements for the design of the Advanced Light Water Reactor (ALWR). The extraordinary database of information garnered throughout 30 years of operations at 111 light water reactors in the this country, and many more overseas, forms the foundation for the ALWR program. This effort -- undertaken in close cooperation with the U.S. Department of Energy -- is managed by the Electric Power Research Institute (EPRI) and includes the participation of several international companies.

But important challenges remain before a renewed commitment to the nuclear option can be fully realized. Plants must continue to be operated to incorporate lessons learned throughout over 5000 reactor-years of commercial operations worldwide. And federal and state regulatory processes must be made stable and predictable to reduce the financial risks of new construction.

Significant progress toward resolving these issues is needed before firm orders for the next generation of nuclear plants can be expected. In response to this need, NPOC has developed a strategic plan for ordering and building new plants by the mid-1990s. The plan identifies all the conditions necessary to achieving this goal and sets a timetable for their implementation. And, in focusing attention on these enabling conditions it fosters coordination and cooperation between government and industry.

We at Westinghouse are pleased to have played a part in the development of the NPOC plan. And, we're encouraged by the growing acceptance of the plan, and its synergy with the National Energy Strategy.

The NPOC plan also endorses the concept of standardization which EPRI has promoted through its ALWR program requirements. But achieving this level of standardization is dependent on extensive first-of-a-kind engineering and reactor designs which are certified by the NRC. And, concurrent with these efforts, industry must proceed with an early site permit program to qualify construction sites at the earliest possible date.

But perhaps most importantly, the AP600 technology is grounded in a proven pressurized water reactor (PWR) technology base that has been demonstrated throughout decades of successful operation around the world. The AP600 is the optimized progression from the Westinghouse two-loop, 600 MWe PWRs that consistently achieve availability factors that are 10 percent higher than the national average. And, because it is based on the world's most widely used nuclear power technology, the AP600 is a mature design that will not require a demonstration plant for NRC licensing or investor utility confidence.

The AP600's technical successes are impressive. The design is in full conformance with current NRC and EPRI requirements for advanced, naturally safe reactors. With 100 percent of the conceptual design effort finished, the AP600 is ready to undergo detailed design, rigorous NRC review, and design certification.

The next step, already underway, is a $120 million, cost-shared, program to perform detailed design for a Standard Safety Analysis Report (SSAR) and for final design certification from the NRC. Last February the DOE awarded us a $50 million cost-sharing contract to continue this design and development effort. Westinghouse has also signed a six-year, $22.5 million contract with EPRI that represents a sizeable utility investment in our technology.

The SSAR is scheduled for completion by mid-1992. Final approval of the design by the NRC staff is expected at the end of 1993, so that by December 1994 the AP600 will receive design certification from the NRC. The Westinghouse AP600 will be the first simplified, naturally safe plant submitted for certification under 10 CFR Part 52.

We'd like to bring the first AP600 on-line by 2000. As part of our Lead Plant Strategy Program -- which uses the AP600 as a model plant for stepped-up development -- we'll continue to foster a high level of cooperation with utilities to realize our common goals. Following this lead plant strategy, key activities such as site certification and completion of first-of-a-kind engineering are undertaken in parallel rather than sequentially. This approach should enable us to bring the first AP600 to commercial operation by the end of the decade.

Currently, an advisory committee of senior utility executives is working with us on [illegible] lead plant implementation strategy. Utilities also attend our workshops where we seek feedback on the responsiveness of our design. And, we find significant support for our ALWR program in the NPOC strategic plan -- in fact, our lead plant strategy complements the approach taken in the NPOC plan.

Current Actions

As I've mentioned earlier, the National Energy Strategy sets the framework for the commercialization of advanced reactor technologies. To implement this strategy, DOE has given priority attention to the ALWR program. Commensurate with this program, DOE has increased the funding support to vendors for activities necessary to achieve timely certification of advanced designs. For these designs to be market-ready in time to meet the demand for new baseload capacity, DOE is focusing on actions that can facilitate new plant orders by 1995.

We at Westinghouse share DOE's commitment to maintaining the momentum of the ALWR program. And we endorse those actions aimed at averting electrical reliability issues in the 1990s and beyond. Four of these actions are key: licensing reform, design certification, the early site demonstration program, and first-of-a-kind engineering. Let me take a moment to talk about each of these items in turn.

Licensing Reform. Predictable licensing and stable regulation are needed to reduce the financial risks associated with new nuclear plant construction and operation, and to enhance the public's ability to address valid safety questions early in the licensing process. The NRC has made significant progress toward resolving this issue through its enactment of 10 CFR Part 52. This regulation enhances plant safety, furthers standardization, and adds stability to the regulatory process. It limits the issues in any preoperational hearing to a determination of whether the plant was built in conformance with the provisions of the combined license. Importantly, the NRC retains its traditional authority to amend the combined license should any new safety information arise.

However, last November, a federal court ruled that although Part 52 responds to "the industry's changing knowledge and the public's changing needs," only Congress could limit preoperational hearings to the extent detailed in Part 52. Since then, with the support of the Department of Justice, the NRC has requested that the Court reconsider its decision.

We would welcome legislative action that clarifies the NRC's authority to limit the scope of a second hearing to conformance issues and to allow the NRC to take such a hearing off the critical path ... without compromising opportunities for meaningful public participation. Part 52 greatly expands the scope of technical information required of applicants. It requires an essentially complete design and all necessary information for the NRC to make safety findings. And, through the preparation of stringent requirements for Inspections, Tests, Analyses, and Acceptance Criteria (ITAACs), it enables plant constructors to provide reasonable assurance that a plant which references a certified design is built and will operate in accordance with that design.

Design Certification. DOE is also sponsoring plant design certification efforts for ALWRs under 10 CFR 52. These efforts are closely coordinated with the ALWR program so that vendor submittals to the NRC are consistent with utility requirements. These interfaces permit designers, constructors and regulators to work together to obtain a fully integrated design which meets safety, performance, constructability and economic criteria. And, the NRC is committed to allocating resources to conduct a thorough review of each design submitted for certification.

Design certification is an essential prerequisite to new plant construction. Westinghouse is participating in the current DOE program to advance the AP600 to a certified design. This program calls for developing plant designs with a level of detail required by 10 CFR Part 52. On February 15, 1991, the NRC signed a staff requirements memorandum (SRM) for SECY-90-377, "Requirements for Design Certification under 10 CFR Part 52." These requirements are, on the whole, consistent with the level of detail defined in the AP600 design certification program.

EPRI is supporting our AP600 design certification effort. And we're working closely with EPRI to ensure that the AP600 design satisfies all the criteria for passive plants found in the ALWR Utility Requirements Document currently under review by the NRC.

Early Site Demonstration Program. 10 CFR 52 also provides for the issuance of early site permits. Such permits contribute to a stable regulatory process by allowing early resolution of site-related issues before the combined construction permit/operating license hearings and before utilities have made significant capital investments in the construction process.

We welcome DOE's initiative to demonstrate the feasibility of this approach by obtaining an Early Site Permit for a U.S. site for one or more ALWRs by the end of 1994. We also support the industry efforts underway to respond to DOE's request for proposals for the "Advanced Light Water Reactor Early Site Permit Program." Westinghouse will cooperate in this program by providing the AP600 design parameters so that our design satisfies the requirements for site certification.

There is no question that the nuclear business is changing. As utilities complete construction of the current generation of nuclear plants, the primary industry focus has shifted to maintaining operational excellence. The reasons are twofold: so that utilities receive a sustained return on their investments, and to pave the way for the next generation of reactors.

We can expect significant changes in the way these next generation facilities are designed, licensed, constructed and operated. Final design for next generation reactors will be completed before construction begins. Cost and schedules will be firm. Field construction practices will give way to a modular approach. And, licensing reform and regulatory preapprovals will add much-needed stability to the regulatory process while providing the opportunity for meaningful public participation before substantial investment capital is committed. The Nuclear Energy Strategy initiatives, the NPOC building blocks, and the Department of Energy's fiscal year 1992 funding requests all recognize and respond to these changes.

First-of-a-kind Engineering. First-of-a-kind engineering for advanced reactor designs will play a major role in the new nuclear industry. It provides the certainty required by the utility industry before committing to new orders. And it is critical to achieving industry goals of standardization. So, together with design certification and early site demonstration programs, completing first-of-a-kind engineering will provide the insurance policy that we need so that the next generation of reactors is available for orders in 1995.

Cost and schedule assurance is a top priority -- and a prerequisite for new plant construction. Through first-of-a-kind engineering, all nonrecurring, first-time engineering will be completed up-front, opening the door to firm price and schedule offerings.

Let me restate that in practical terms. When first-of-a-kind engineering is completed, Westinghouse and its partners could offer a turnkey proposal for the AP600 that provides specifics project costs, completion date, and performance.

Achieving cost and schedule certainty is significant in a very real financial sense. By avoiding overruns and agreeing to a design in advance of construction, the probability of regulatory disallowances is greatly reduced. And that will result in considerable savings. In the 1980s, for example, Public Utility Commission disallowances for schedule delays and cost overruns at 23 nuclear units totaled $7.2 billion. That's about $320 million per unit. These figures dramatize the impact of cost and schedule uncertainties, and clearly illustrate the benefits of first-of-a-kind engineering.

First-of-a-kind engineering will also facilitate the modular engineering approach needed for new, more cost-effective construction. Plants will be built through factory-produced modules that can be erected at the site in only 36 months ... a process that also substantially enhances our control over quality. A detailed design package supplied prior to the onset of construction will lead to many advantages with little or no risk:

- Firm quantities of construction materials
- Firm and advanced construction planning and scheduling
- Firm estimates of construction labor and field supervision
- Firm module designs and elimination of nonrecurring engineering

Finally, first-of-a-kind engineering so completely defines plant details that only equipment procurement and site specific design work remains. Therefore, first-of-a-kind engineering -- coupled with design certification -- results in a standardized design.

A comprehensive industry commitment to standardization is one of the key elements of the NPOC strategic plan. This commitment exists because industry has long recognized the economic advantages of standard designs. France provides the most obvious example. Although standardization had been on a much smaller scale here in the U.S. (with projects such as SNUPPS), the clear advantages of large-scale implementation have been recognized:

- Regulatory stability and elimination of unnecessary changes through early definition of requirements
- Resolution of issues in a timely and systematic manner
- Design optimization
- Simple and uniform designs that are easier to build and operate
- Focused and efficient application of technical and financial resources
- An expanded resource base that enhances support capabilities
- Accelerated, maximized feedback from past experience

To ensure utilities are provided with a continuing, renewed nuclear option by the mid-1990s, first-of-a-kind engineering must be initiated in 1991. We fully support the DOE initiative for a cost-shared program on first-of-a-kind engineering. And we urge Congress to approve the $20 million budgeted for this program in fiscal year 1992.

Summary and Conclusion

We all know that we're getting closer to the point where decisions will have to be made about large central station power plants. In a balanced energy picture, some of those plants should be nuclear.

The National Energy Strategy points to the need for expanded baseload electrical capacity at the outset of the next century. And, the DOE's fiscal year 1992 funding request places priority on those actions which would enable new plant orders to begin by 1995. We urge Congress to support the funding request for the ALWR program and the increased funding for design certification.

Licensing reform is critical. We support the licensing reform initiatives contained in the National Energy Strategy, and urge Congress to support legislation that clarifies the NRC's authority to limit hearings after a plant has been built.

Completion of first-of-a-kind engineering is also critical . It responds to the imperative of cost and schedule certainty and contributes significantly to the objectives of standardization. We welcome the DOE initiative on first-of-a-kind engineering and ask your support for the fiscal year 1992 budget request of $20 million.

Taken together, the combination of first-of-a-kind engineering, design certification, and early site certification -- all completed by the mid-1990s -- will enable utilities to embark on a new generation of simple, standard, more economical nuclear power plants. And, of course, it's crucial that we continue our commitment to performance excellence at today's operating power plants.

The facts are plain ... significant progress is being made toward renewing the nuclear option. The National Energy Strategy sets a positive framework. DOE, EPRI and the industry are rapidly advancing the technology through continued strong support from Congress. And, NPOC has developed a solid plan whose goals can be achieved through cooperation and collective action.

The promise of reliable, low-cost, environmentally sound generation of electricity from nuclear power is valid and viable. Working together, we can fulfill the promise.

In closing, I'd like to briefly discuss several additional nuclear programs which Westinghouse supports.

- o We're working with General Electric and several other U.S. companies to develop a Liquid Metal Reactor (LMR). Basic LMR technology was demonstrated by the Fast Flux Test Facility at Hanford, and LMRs will be vital to the U.S. in the 21st century. We urge DOE and Congress to restore funding for the LMR program to the contract award level of $16 million for fiscal year 1992.

- o We also handle quality assurance overchecking on isotopic power systems. These systems have contributed to the success of the Voyager 2 and Galileo missions. We believe present funding levels for this program are adequate.

- o And, we are a major subcontractor to General Electric on the SP-100, a liquid-metal-cooled reactor which has been identified as having excellent potential for lunar and satellite applications. We strongly support this vital program and urge that DOE's $52 million funding request for fiscal year 1992 be granted.

- o Finally, we urge increased DOE support for nuclear thermal propulsion systems ... the most promising technology for powering this Administration's stated goal of manned space flights to Mars and beyond. Westinghouse is poised to be a key player in this exciting adventure and fully supports DOE's $7 million budget.

Westinghouse values its long association with the Department of Energy on programs of national importance. We view nuclear programs in this manner, and we welcome this opportunity to discuss their role, and our role, in supporting our nation's vital interests.

Thank-you.

Mrs. LLOYD. Thank you very much, Mr. Woodson.

Dr. Wolfe?

STATEMENT OF DR. BERTRAM WOLFE, VICE PRESIDENT AND GENERAL MANAGER, GE NUCLEAR ENERGY, GENERAL ELECTRIC CO., SAN JOSE, CA

Dr. WOLFE. My name is Bertram Wolfe, and I am vice president and general manager of General Electric's Nuclear Energy Operations. I have been actively involved in the research, development, and application of nuclear power generation for over 30 years. I am a past president of the American Nuclear Society, a member of the National Academy of Engineering, and am on the Energy Engineering Board of the National Research Council. I am also on the board of the Nuclear Power Oversight Committee, as well as those of several other industry organizations providing guidance in the nuclear energy field. I greatly appreciate the opportunity to testify before you today on the Civilian Advanced Reactor Research and Development programs and the Department of Energy's proposed fiscal year 1992 budget. I also greatly appreciate the support of this committee over the years on research and development programs in this key technology area. We want to work with you in assuring future U.S. energy security.

I joined the nuclear industry in 1955 at the start of the peaceful nuclear power era and have watched nuclear power go through its highs and lows. We started with enthusiasm in the late 1950s, saw a negligible market in the 1960s, and witnesses the start of a boom in nuclear power in the late 1960s and early 1970s, only to see demand decline after the 1973 Arab oil boycott.

The point I want to make is that these ups and downs of nuclear power correlated directly with need. When President Eisenhower's Atoms for Peace Program started in 1954, there were only a hundred gigawatts of installed electrical capacity in the United States. Our supplies of all fossil fuels, including oil, appeared limitless, and the cost of electricity from coal was less than $0.01 per kilowatt hour. Clearly, there was no near-term need for nuclear power.

However, electricity use was doubling every 10 years, and by the mid-1960s there were increasing cleanup costs and public reaction to pollution by fossil plants, in particular, "dirty" coal. Nuclear power became a needed alternate and in the early 1970s, some 40 nuclear plants per year were being ordered.

After the Arab oil boycott of 1973, the growth rate of electrical usage was cut in half. Because utilities had pre-ordered plants on the basis of the previous 10-year doubling time, they ordered no more large power plants and cancelled some 80 coal plants and some 100 nuclear plants which were on order. Even then, until recently there has been considerable excess electrical capacity in this country. Thus one could be against coal, against oil, against nuclear, against gas pipelines, against dams, and even against new geothermal power near fumeroles and potholes, and it didn't matter. This era of excess capacity is coming to an end. We are going to need new electrical supplies, and this is why I believe your proposed legislation is important and timely.

It should be noted that the 1973 Arab oil embargo affected other countries differently than the U.S., which has very large indigenous coal supplies. France has few indigenous fuel resources and had an electrical supply system almost completely dependent upon imported oil. The Arab oil boycott pointed to the need to become less dependent on oil and led to a massive expansion of nuclear energy. Nuclear power now provides some 80 percent of France's total electric generation. In Japan, also with few indigenous energy supplies and also heavily dependent on imported oil, the boycott led to a diversification of energy sources in which nuclear energy now supplies 30 percent of electrical needs. With a projection of 308 large new nuclear plants in the next two decades, nuclear's share will rise to 40 percent.

In the United States, as our economy grows we are steadily becoming more electricity intensive, and there are now indications that our generation capacity is not keeping up with this growth of electricity use. Without new capacity commitments it is projected that in the 1990s, even at a growth rate between 2 and 3 percent, we will fall significantly below the 17 percent excess capacity margin required for reliable supply. Since the summer of 1988, for the first time in the past two decades, we have had electrical shortages in some parts of the country, and without new capacity such shortages are expected to become more common. In fact, there are estimates of need of 150-250 GWe of new capacity for the next two decades, the equivalent of 150 to 200 large—1,000 to 1,350 MWe—power stations, each of which could supply the electricity for a city of over half a million people.

The two major supply alternatives for base load capacity now available are coal and nuclear energy. However, with growing concern about the greenhouse effect from burning fossil fuels, we may find ourselves in a situation where nuclear energy is the only practical means to satisfy expanded electrical use. On a global basis with increasing needs of the developing nations, this may be particularly so.

If, in fact, there is a need to provide new energy requirements for this Nation and the world, I am pleased to report that from a technological standpoint General Electric will be ready. Because of key programs abroad, along with those in this country supported by the Congress and this committee in particular, I believe we will be able to bring much improved technology in advanced nuclear plants to the Nation and the world.

Over the past decade General Electric, with its Japanese associates Hitachi and Toshiba, has developed the Advanced Boiling Water Reactor, or ABWR. The first of these plants, based on several hundred millions of dollars of development and design work, is scheduled to start construction this year at Tokyo Electric Power Company's Kashiwasaki site. The second ABWR at that site will begin construction next year. In Japanese style, these plants will provide needed power to Tokyo starting in 1996 and 1997 respectively. In addition, General Electric, in an exciting international effort supported by the Department of Energy, is developing a smaller 600 MWe nuclear plant, the Simplified Boiling Water Reactor, or SBWR, which builds on the ABWR technology while taking advantage of passive safety and simpler operating features to maintain competitive cost and operating benefits at the smaller capacity.

Both of the plants noted above take advantage of the 30-plus years of nuclear power experience to glean the best from the past and combine it with new technology such as advanced materials and solid state electronics. Thus, again let me express my pleasure at being able to report to you that GE remains a technological leader in developing safer, more reliable, and more economic nuclear plants for the future.

The key problems inhibiting the increased use of nuclear power in this country are institutional, not technical. At the forefront of these institutional impediments is our licensing system. In Japan and France, it typically takes four to six years to build a nuclear power plant and put it into operation, and these plants produce the lowest cost electricity. In the U.S., with our licensing system, it now takes an uncertain 10 or 15 years and enormous attendant costs before a plant is allowed to operate. Any opponent with a smart lawyer can cause interminable delays in the licensing of even a fully constructed nuclear plant by raising 11th-hour questions, regardless of whether they are actually substantive or germane to the basic issue of plant safety. Thus, despite the growing need for new capacity, no U.S. utility is prepared to take the open-ended financial risk of committing to a new nuclear plant.

In 1986 Lando Zech, the then-chairman of the Nuclear Regulatory Commission, took the lead in correcting the system by initiating a new procedure calling for the safety analyses and NRC approval/certification of standardized nuclear plant designs before plant construction begins. The licensing of GE's ABWR became the first trial case under the new procedure. Now, after some four years of favorable technical reviews, the design approval process is behind schedule in the NRC, and a recent court decision—under appeal—concludes that a key part of the related plant licensing procedure is invalid. Yet unless licensing stability is realized, no new nuclear power plants will be built in the United States, regardless of need.

Fortunately, there are some initiatives aimed at correcting our nuclear licensing situation. As noted, a program to pre-license standardized plant designs is underway. This is a program encouraged by the NRC and supported by GE, EPRI, and the Department of Energy. In undergoing this new procedure, as the trial case, the ABWR licensing program has been bogged down by a number of policy issues within the NRC. We are working with the commissioners and staff to minimize the impact. We are hopeful that the ABWR will receive the first standardized plant certification in 1992, to be followed by the SBWR in the 1995 period. As part of the licensing process we are working with the NRC to establish ground rules and regulatory procedures for construction of the certified plant. These involve inspections, tests, and analyses and acceptance criteria conditions, or ITAACS, to assure that the plant is built to the licensing specification. With the completion of the standardized plant certification process, plants in the United States should be constructed in the four- to six-year time scale regularly achieved overseas, instead of the 10- to 15-year periods and longer which have been characteristic here for the past two decades.

However, my concern is that we have not yet had the new licensing system tested in the courts. I noted that there is already one adverse court decision, and undoubtedly any new reactor project, despite its need, will be attacked in the courts with the hope of derailing it. I believe congressional intent will need to be clarified through appropriate legislation to remove grounds for extended litigation. Title XIII of the Senate's proposed Energy Security Act of 1991 is such legislative clarification, and we would hope this committee will support similar clarifying legislation.

The problem facing us in this country is our 18-year history of delays, escalating requirements and costs, and abandonments during the construction phase of a nuclear project. Whereas abroad nuclear plants are built on firm schedules with firm prices, no sane nuclear plant manufacturer or constructor would today make such an offer in the United States, and with past experience, no utility is ready to undertake the risk. Thus we need a means to demonstrate that with the new standardized licensing procedure, plants in the United States can be built efficiently in the four- to six-year timeframe that is achieved abroad. Congressional legislation which provides for Government "insurance" if new regulatory requirements are imposed after the issuance of a license is one means of supporting such a demonstration.

Let me reiterate. The problem is not the basic technology or economics of the nuclear plant, but rather it is the need to demonstrate that we can license and build plants in the United States with the same certainty and firm schedules as we have abroad.

As I have indicated, the advanced light water reactor, or ALWR, is clearly the technology to be used in the next few decades. It has received extensive development, has a well established 30-year industrial infrastructure and experience base, and is already developing the new designs based on this experience. The DOE budget for fiscal year 1992 is consistent with the ABWR and SBWR program plans for successful certification in 1992 and 1995 respectively, and we urge your continued support. However, the revival of nuclear energy in the United States and its widespread use throughout the world raises the issue of the long-term future of nuclear energy. The light water reactors and other thermal reactor systems rely on the economic availability of uranium. Although there appears to be sufficient economic uranium to supply ALWRs for some decades, the long-term promise of nuclear energy is an essentially unlimited energy supply through the Advanced Liquid Metal Reactor, or ALMR. Since we have learned that it takes several decades to develop, test, correct, and improve new reactor concepts, our national energy policy and supporting development programs should include timely and consistent ALMR development and demonstration.

The ALMR is unique in that it can be made to manufacture, or breed, substantially more fissile material than it consumes. This is done by converting the 99 percent non-fissile portion of uranium into fissile material in the reactor. The utilization of this capability of modern ALMRs to breed will be essential sometime in the next century, as the growth in nuclear energy generation using advanced light reactors, or other non-breeding reactors, consumes the currently abundant uranium supply.

The ALMR is also unique in that it has the potential capability of utilizing as fuel the long-life radioactive actinides that are in the residual waste in spent fuels. While it does not change the need for a geological repository, this capability could change in a dramatic way the quantity, composition, and period required for safe storage of nuclear waste, and the public perception of the waste situation.

The current DOE program for development of a commercially deployable ALMR is based upon development of a national design by an industrial team comprised of General Electric, Westinghouse, Bechtel, Burns & Roe, United Engineers and Constructors, Babcock and Wilcox, and others, with extensive technology support from the national laboratories, such as Argonne National Laboratory in its IFR activity; Oak Ridge in its advanced controls work; and Westinghouse Hanford with its sodium test facilities. This concept also has attracted the attention of international parties and collaborative efforts have already been initiated which count on a viable and ongoing U.S. ALMR program.

Congressional support is needed to maintain the viability and momentum of this promising program through consistent support to the industrial team's design development with similar support to the required technology development at the national laboratories. The DOE fiscal year 1992 budget as submitted may be inadequate to maintain the program's momentum. The industrial design team has reprogrammed the completion of the ALMR's advance conceptual design, phase 1, to the end of September 1992, based on $14 million funding for fiscal year 1992. This supports DOE's projection of completing the preliminary design, phase 2, by fiscal year 1994, and leads into the longer range prototype program for licensing certification through a Government/private sector partnership shortly after the turn of the century, in 2005. National laboratory funding for fiscal year 1992 is also needed at levels no less than current fiscal year 1991 amounts if we are to maintain focused technology support and complete the low-risk, success-oriented ALMR program underway.

I have covered a number of areas during this testimony. Let me summarize.

I believe a U.S. national energy policy should recognize that the demand for electricity will likely continue to grow; that the world petroleum problems will continue over the long term; and that because of the greenhouse effect and other environmental problems, we may not be able to rely on fossil fuels as the predominant source of new energy supplies. Nuclear power is being held back in the United States, not by technical, but by institutional issues. The revival of nuclear power will depend upon need, and for the past 17 years there has been no need. But when the American public recognizes that its welfare will depend upon the development of new, secure energy sources, and in particular, upon the revival of nuclear power; when it recognizes that world stability and the welfare of the world in general and of the underdeveloped nations in particular depends upon new, non-polluting energy sources—then I believe that the American public will demand and will force a solution to the institutional problems.

Perhaps we will find in the future that we have been too pessimistic. Perhaps the greenhouse effect will turn out to be less serious than projected. Perhaps other environmental energy problems, such as acid rain, will be solved. Perhaps we will find immense new, acceptable energy supplies, such as natural gas from the center of the earth. Or perhaps conservation together with solar and wind power will be able to provide economically for expanding world energy needs.

Today, however, these potentialities taken together do not lead to a high probability of solution to the Nation's or the world's future energy supply problems. Under the circumstances, it would in my view be irresponsible if we do not take the steps necessary to provide for the expanded use of nuclear energy for national and world welfare. The reactor programs discussed here provide the technical basis for the future.

Once again, let me thank you for your past support and urge your continued attention to program needs.

I appreciate the opportunity to testify before you on this vital subject and welcome the opportunity to respond to questions.

[The prepared statement of Dr. Wolfe follows:]

TESTIMONY OF

BERTRAM WOLFE
VICE PRESIDENT AND GENERAL MANAGER
GE NUCLEAR ENERGY
GENERAL ELECTRIC COMPANY
SAN JOSE, CALIFORNIA

ON
CIVILIAN REACTOR
RESEARCH AND DEVELOPMENT PROGRAMS

BEFORE THE
SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT
HOUSE COMMITTEE ON SCIENCE, SPACE AND TECHNOLOGY

My name is Bertram Wolfe, and I am Vice President and General Manager of General Electric's Nuclear Energy Operations. I have been actively involved in the research, development and application of nuclear power generation for over 30 years. I am a past president of the American Nuclear Society, a member of the National Academy of Engineering, and am on the Energy Engineering Board of the National Research Council. I am also on the board of the Nuclear Power Oversight Committee (NPOC) as well as those of several other industry organizations providing guidance in the nuclear energy field. I greatly appreciate the opportunity to testify before you today on the Civilian Advanced Reactor Research and Development programs and the Department of Energy's proposed Fiscal Year 1992 Budget. I also greatly appreciate the support of this committee over the years on research and development programs in this key technology area. We want to work with you in assuring future U.S. energy security.

I joined the nuclear industry in 1955 at the start of the peaceful nuclear power era and have watched nuclear power go through its highs and lows. We started with enthusiasm in the late Fifties, saw a negligible market in the Sixties, and witnessed the start of a boom in nuclear power in the late Sixties and early Seventies -- only to see demand decline after the 1973 Arab oil boycott.

The point I want to make is that these ups and downs of nuclear power correlated directly with need. When President Eisenhower's Atoms for Peace Program started in 1954, there were only a hundred gigawatts of installed electrical capacity in the United States. Our supplies of all fossil fuels, including oil, appeared limitless, and the cost of electricity from coal was less than one cent per kilowatt hour. Clearly there was no near-term need for nuclear power.

However, electricity use was doubling every ten years, and by the mid-sixties there were increasing cleanup costs and public reaction to pollution by fossil plants, in particular, "dirty" coal. Nuclear power became a needed alternate and in the early seventies some 40 nuclear plants per year were being ordered.

After the Arab oil boycott of 1973, the growth rate of electrical usage was cut in half. Because utilities had pre-ordered plants on the basis of the previous ten-year doubling time, they ordered no more large power plants and cancelled some 80 coal plants and some 100 nuclear plants which were on order. Even then, until recently, there has been considerable excess electrical capacity in this country. Thus, one could be against coal, against oil, against nuclear, against gas pipelines, against dams, and even against new geothermal power near fumeroles and potholes -- and it didn't matter. This era of excess capacity is coming to an end. We are going to need new electrical supplies and this is why I believe your proposed legislation is important and timely.

It should be noted that the 1973 Arab oil embargo affected other countries differently than the U.S., which has very large indigenous coal supplies. France has few indigenous fuel resources and had an electric supply system almost completely dependent upon imported oil. The Arab oil boycott pointed to the need to become less dependent on oil and led to a massive expansion of nuclear energy. Nuclear power now provides some 80% of France's total electric generation. In Japan, also with few indigenous energy supplies and also heavily dependent on imported oil, the boycott led to a diversification of energy sources in which nuclear energy now supplies 30% of electrical needs. With a projection of 30 large new nuclear plants in the next two decades, nuclear's share will rise to 40%.

In the United States, as our economy grows, we are steadily becoming more electricity intensive, and there are now indications that our generation capacity is not keeping up with this growth of electricity use. Without new capacity commitments, it is projected that in the 90's, even at a growth rate between 2 and 3%, we will fall significantly below the 17% excess capacity margin required for reliable supply. Since the summer of 1988, for the first time in the past two decades, we have had electrical shortages in some parts of the country, and without new capacity such shortages are expected to become more common. In fact, there are estimates of need of 150-250 GWe of new capacity for the next two decades, the equivalent of 150 to 200 large (1000-1350 MWe) power stations, each of which could supply the electricity for a city of over a half-million people.

The two major supply alternatives for base load capacity now available are coal and nuclear energy. However, with growing concern about the greenhouse effect from burning fossil fuels, we may find ourselves in a situation where nuclear energy is the only practical means to satisfy expanded electrical use. On a global basis with increasing needs of the developing nations, this may be particularly so.

If, in fact, there is a need to provide new energy requirements for this nation and the world, I am pleased to report that from a technological standpoint General Electric will be ready. Because of key programs abroad, along with those in this country supported by the Congress and this committee in particular, I believe we will be able to bring much improved technology in advanced nuclear plants to the nation and the world.

Over the past decade General Electric, with its Japanese associates, Hitachi and Toshiba, have developed the Advanced Boiling Water Reactor (ABWR). The first of these plants, based on several hundred millions of dollars of development and design work, is scheduled to start construction this year at Tokyo Electric Power Company's Kashiwasaki site. The second ABWR at that site will begin construction next year. In Japanese style, these plants will provide needed power to Tokyo starting in 1996 and 1997 respectively. In addition, General Electric, in an exciting international effort supported by the Department of Energy, is developing a smaller 600 MWe nuclear plant, the Simplified Boiling Water Reactor (SBWR), which builds on the ABWR technology while taking advantage of passive safety and simpler operating features to maintain competitive cost and operating benefits at the smaller capacity.

Both of the plants noted above take advantage of the thirty plus years of nuclear power experience to glean the best from the past and combine it with new technology such as advanced materials and solid state electronics. Thus, again let me express my pleasure at being able to report to you that the GE remains a technological leader in developing safer, more reliable, and more economic nuclear plants for the future.

The key problems inhibiting the increased use of nuclear power in this country are institutional, not technical. At the forefront of these institutional impediments is our licensing system. In Japan and France, it typically takes four to six years to build a nuclear power plant and put it into operation, and these plants produce the lowest cost electricity. In the U.S., with our licensing system, it now takes an uncertain ten or fifteen years and enormous attendant costs before a plant is allowed to operate. Any opponent with a smart lawyer can cause interminable delays in the licensing of even a fully constructed nuclear plant by raising eleventh-hour questions, regardless of whether they are actually substantive or germane to the basic issue of plant safety. Thus, despite the growing need for new capacity, no U.S. utility is prepared to take the open-ended financial risk of committing to a new nuclear plant.

In 1986, Lando Zech, the then chairman of the Nuclear Regulatory Commission (NRC), took the lead in correcting the system by initiating a new procedure calling for the safety analyses and NRC approval (certification) standardized nuclear plant designs before plant construction begins. The licensing of GE's ABWR became the first trial case under the new procedure. Now, after some four years of favorable technical reviews, the design approval process is behind schedule in the NRC, and a recent court decision (under appeal) concludes that a key part of the related plant licensing procedure is invalid. Yet unless licensing stability is realized, no new nuclear power plants will be built in the United States, regardless of need.

Fortunately, there are some initiatives aimed at correcting our nuclear licensing situation. As noted, a program to pre-license standardized plant designs is underway. This is a program encouraged by the NRC and supported by GE, EPRI, and the Department of Energy. In undergoing this new procedure, as the trial case, the ABWR licensing program has been bogged down by a number of policy issues within the NRC. We are working with the Commissioners and Staff to minimize the impact. We are hopeful that the ABWR will receive the first standardized plant certification in 1992, to be followed by the SBWR in the 1995 period. As part of the licensing process, we are working with the NRC to establish ground rules and regulatory procedures for construction of the certified plant. These involve inspections, tests, and analyses and acceptance criteria conditions (ITAACS) to assure that the plant is built to the licensing specification. With the completion of the standardized plant certification process, plants in the U.S. should be constructed in the four to six-year time scale regularly achieved overseas, instead of the ten to fifteen-year periods and longer which have been characteristic here for the past two decades.

However, my concern is that we have not yet had the new licensing system tested in the courts. I noted that there is already one adverse court decision, and undoubtedly any new reactor project - despite its need - will be attacked in the courts with the hope of derailing it. I believe Congressional intent will need to be clarified through appropriate legislation to remove grounds for extended litigation. Title XIII of the Senate's proposed Energy Security Act of 1991 is such legislative clarification, and we would hope this Committee will support similar clarifying legislation.

The problem facing us in this country is our 18-year history of delays, escalating requirements and costs, and abandonments during the construction phase of a nuclear project. Whereas abroad nuclear projects are built on firm schedules with firm prices, no sane nuclear plant manufacturer or constructor would today make such an offer in the U.S., and with the past experience no utility is ready to undertake the risk. Thus, we need a means to demonstrate that with the new standardized licensing procedure, plants in the U.S. can be built efficiently in the four to six-year time frame that is achieved abroad. Congressional legislation which provides for Government "insurance" if new regulatory requirements are imposed after the issuance of a license is one means of supporting such a demonstration. Let me reiterate: the problem is not the basic technology or economics of the nuclear plant; but rather it is the need to demonstrate that we can license and build plants in the U.S. with the same certainty and firm schedules as we have abroad.

As I have indicated, the advanced light water reactor (ALWR) is clearly the technology to be used in the next few decades. It has received extensive development, has a well established 30-year industrial infrastructure and experience base, and is already developing the new designs based on this experience. The DOE budget for fiscal year 92 is consistent with the ABWR and SBWR program plans for successful certification in 1992 and 1995 respectively, and we urge your continued support. However, the revival of nuclear energy in the U.S. and its widespread use throughout the world raises the issue of the long-term future of nuclear energy. The light water reactors (and other thermal reactor systems) rely on the economic availability of uranium. Although there appears to be sufficient economic uranium to supply ALWRs for some decades, the long-term promise of nuclear energy is an essentially unlimited energy supply through the Advanced Liquid Metal Reactor (ALMR). Since we have learned that it takes several decades to develop, test, correct and improve new reactor concepts, our national energy policy and supporting development programs should include timely and consistent ALMR development and demonstration.

The ALMR is unique in that it can be made to manufacture (or breed) substantially more fissile material than it consumes. This is done by converting the 99% non-fissile portion of uranium into fissile material in the reactor. The utilization of this capability of modern ALMRs to breed will be essential sometime in the next century, as the growth in nuclear energy generation using advanced light water reactors, or other non-breeding reactors, consumes the currently abundant uranium supply.

The ALMR is also unique in that it has the potential capability of utilizing as fuel the long-life radioactive actinides that are in the residual waste in spent fuels. While it does not change the need for a geological repository, this capability could change in a dramatic way the quantity, composition and period required for safe storage of nuclear waste, and the public perception of the waste situation.

The current DOE program for development of a commercially deployable ALMR is based upon development of a national design by an industrial team comprised of General Electric, Westinghouse, Bechtel, Burns & Roe, United Engineers and Constructors, Babcock and Wilcox and others with extensive technology support from the National laboratories; such as Argonne National Laboratory in its IFR activity, Oak Ridge in its advanced controls work, and Westinghouse Hanford with its sodium test facilities. This concept also has attracted the attention of international parties and collaborative efforts have already been initiated which count on a viable and ongoing U.S. ALMR program.

Congressional support is needed to maintain the viability and momentum of this promising program through consistent support to the industrial team's design development with similar support to the required technology development at the National Laboratories. The DOE Fiscal Year 1992 budget as submitted may be inadequate to maintain the programs's momentum. The industrial design team has reprogrammed the completion of the ALMR's advance conceptual design (Phase 1) to the end of September 1992, based on $14.0 million funding for FY92. This supports DOE's projection of completing the preliminary design (Phase 2) by FY94, and leads into the longer range prototype program for licensing certification through a government/private sector partnership shortly after the turn of the century (2005). National Laboratory funding for FY92 is also needed at levels no less than current year (FY91) amounts if we are to maintain focused technology support and complete the low risk, success-oriented ALMR program underway.

I have covered a number of areas during this testimony. Let me summarize. I believe a U.S. national energy policy should recognize that the demand for electricity will likely continue to grow; that the world petroleum problems will continue over the long term; and that because of the greenhouse effect and other environmental problems we may not be able to rely on fossil fuels as the predominant source of new energy supplies. Nuclear power is being held back in the U.S., not by technical, but by institutional issues. The revival of nuclear power will depend upon need, and for the past 17 years there has been no need. But when the American public recognizes that its welfare will depend upon the development of new, secure energy sources, and in particular, upon the revival of nuclear power; when it recognizes that world stability and the welfare of the world in general and of the underdeveloped nations in particular, depends upon new, non-polluting energy sources; then I believe that the American public will demand and will force a solution to the institutional problems.

Perhaps we will find in the future that we have been too pessimistic. Perhaps the greenhouse effect will turn out to be less serious than projected; perhaps other environmental energy problems such as acid rain will be solved; perhaps we will find immense new, acceptable energy supplies such as natural gas from the center of the earth; or perhaps conservation together with solar and wind power will be able to economically provide for expanding world energy needs. Today, however, these potentialities taken together do not lead to a high probability of solution to the nation's or the world's future energy supply problems. Under the circumstances, it would in my view be irresponsible if we do not take the steps necessary to provide for the expanded use of nuclear energy for national and world welfare. The reactor programs discussed above provide the technical basis for the future. Once again, let me thank you for your past support and urge your continued attention to the program needs.

I appreciate the opportunity to testify before you on this vital subject and welcome the opportunity to respond to questions.

Mrs. LLOYD. Thank you, Dr. Wolfe.

Mr. McDonald?

STATEMENT OF R. PATRICK McDONALD, EXECUTIVE VICE PRESIDENT, SOUTHERN NUCLEAR OPERATING CO., INC.

Mr. McDONALD. Thank you, Madam Chairman. My name is Pat McDonald. I am Executive Vice President of Southern Nuclear Operating Company of the Southern Company. In the Southern Company we have six operating reactors. We will be looking for new base load generation around the turn of the century. We like nuclear energy very much, and we are very much into looking towards the future.

In the past several months, the leadership of our industry has done something quite dramatic. Acting through the Nuclear Power Oversight Committee, which you've heard referred to here this morning as NPOC, we have developed and initiated a plan entitled "Strategic Plan for Building New Nuclear Plants". Copies are being provided to your staff. The purpose of this plan is to establish a reasonable business option for building new advanced light water reactors and to make that option adequately attractive so that there will be plants ordered.

Our industry, in going into this, has a very high degree of consensus and cohesion. It's acting in a very responsible manner to assure that we won't be caught flat footed as the emerging demand for base load generation comes about. Our goal is to be able to order plants, that is, make commitments, by about 1995 or the mid-1990s. That would allow us to meet the demand by the turn of the century.

Our plan is comprehensive. That's the NPOC plan. It has a framework of fourteen building blocks. Each building block is an enabling condition needed for a new infrastructure in which we can build plants. Typical building blocks are named high level radioactive waste, NRC design certification, first-of-a-kind engineering, standardization beyond design, enhanced public acceptance, etc. Each block has goals and milestones and assigned responsibility to an organization with frequent reporting. The blocks are inter-related, such as to require close dynamic teamwork among industry organizations.

In addition to this, for several years, through our advanced light water reactor program managed by the Electric Power Research Institute (EPRI), U.S. utilities have been working on the development of an advanced technological foundation for the next generation of plants. This program has been closely coordinated and supported by DOE. The DOE budget proposal before this committee addresses new, as well as ongoing, technological activities that are vital to our NPOC plan.

Each of these activities in the DOE budget are also NPOC building blocks. Those funded in the prior years are the advanced light water reactor utility requirements, NRC design certification and siting. DOE has been participating in these first two activities for several years. This subcommittee recognized years ago the value of these projects, which have now become key building blocks for timely re-establishment of the nuclear option.

DOE has proposed funding for first-of-a-kind engineering. You've heard several comments about that. I'd like to make a couple more. First-of-a-kind engineering is the detailed design beyond that needed for certification, the certification now in progress. It is not plant specific. It can be used over and over again for building each new plant in a family of standardized plants.

The detail and scope of this kind of a design in first-of-a-kind engineering is necessary, and you've heard this said before, for making realistic estimates of building costs and schedules in the first-of-a-family of standardized plants. That is, we expect to have families of plants with several of exactly the same type in the family. Building and making these cost estimates is vital when we are looking at an option. That is, comparing the cost of the plant and the cost of production of energy with other alternates which we might have.

This first-of-a-kind engineering is the last engineering step to be done that is not site specific. DOE has stipulated, as you heard Mr. Young testify, that the industry, meaning utilities, reactor manufacturers, etc., must match the funds DOE would provide. In the response to that, the utilities are presently initiating a solicitation drive to raise a portion of the private sector funding necessary to meet that challenge of that condition.

As you've also heard, within the advanced light water reactor program, we have two evolutionary and two passive plant designs, which I believe will become the very best in the world. They will meet the requirements which we, the utilities, have asked those plants to be designed by. They're proceeding through certification.

My company prefers the mid-sized passive plants, because of several factors. They fit our expected low growth pattern best. They require smaller increments of financing and rate based additions. They have very attractive, passive design features that directly utilize natural forces. We also believe they are more adaptable to standardization, because of a broader market for that size and type of plant. Standardization is one of the most important features we look for in new plants.

Madam Chairman, I have direct and first hand knowledge and involvement in all these activities discussed. I urge the committee to support the DOE budget proposal.

I do have one additional thing to ask your support for. I would like to call your attention to the subject of one step licensing. It is a vital building block in our NPOC plan. I have discussed this in some detail in my written testimony.

Thank you for your continuing support for the DOE activities. I've enjoyed speaking with you and would be happy to answer any questions you might have.

[The prepared statement of Mr. McDonald follows:]

TESTIMONY BEFORE
UNITED STATES HOUSE OF REPRESENTATIVES
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
SUBCOMMITTEE ON ENERGY

BY

R. PATRICK MCDONALD
EXECUTIVE VICE PRESIDENT
SOUTHERN NUCLEAR OPERATING COMPANY, INC.
BIRMINGHAM, ALABAMA

March 6, 1991

INTRODUCTION

My name is Pat McDonald and I am appearing before this Subcommittee as Executive Vice President of Southern Nuclear Operating Company, Inc., which is a wholly owned subsidiary of The Southern Company. I appear also as Executive Vice President of Alabama Power Company, which is the NRC-licensed operator of the J. M. Farley nuclear plant, and as an Executive Vice President of Georgia Power Company, which is the NRC-licensed operator of the A. W. Vogtle, Jr. Nuclear Plant and the Edwin I. Hatch Nuclear Plant. Currently, Southern Nuclear Operating Company is providing technical and support services to Georgia Power Company and Alabama Power Company in the operation of their nuclear power plants, although we anticipate that Southern Nuclear will ultimately become the NRC-licensed operator for all three plants.

I hold a Bachelor of Science degree in engineering from the U. S. Naval Academy and a Master of Science degree in international affairs from George Washington University. I am also a graduate of the National War College. I have received advanced education and training in nuclear power from the U. S. Navy, where I served aboard nuclear submarines and later was commanding officer of Submarine Squadron TEN in the U. S. Atlantic Fleet. I have been actively involved in nuclear power since 1956 as a Navy officer and then, for the past seventeen years, in commercial nuclear power. I am a member of the Utility Steering Committee for our industry's Advanced Light Water Reactor (ALWR) program. I am also a member of the Ad Hoc Committee for NPOC (Nuclear Power Oversight Committee) Strategic Plan.

NPOC includes the leaders of eight associations representing the principal nuclear utility participants in the U. S. nuclear industry. In addition to representation from various utility associations, membership includes nuclear power plant designers and nuclear power plant architect engineer/builders. The purpose of NPOC is to provide a vehicle for consideration of policy issues at the highest executive level within the represented associations and the nuclear industry to insure that significant issues are given proper attention and to foster unified positions on these significant issues. NPOC accomplishes this purpose by coordinating the institutional arrangements and activities, insuring the development of coordinated strategic plans for industry associations and activities, and providing oversight for the nuclear industry.

It is an honor to be given the opportunity to appear before this Subcommittee. As a proponent of nuclear energy, I am greatly appreciative of the time and effort this Subcommittee is spending discussing the future of nuclear power, the important role it can play in our nation's energy future, and the obstacles which may prevent its reemergence. I am gratified to see this Subcommittee's sincere desire to understand more fully what measures are needed to ensure that nuclear power is a viable and realistic option for addressing our country's ever-increasing need for electric energy.

PURPOSE

The purpose of my testimony is two-fold. First, I will provide the Subcommittee with the perspective of an investor-owned utility on the Strategic Plan for Building New Nuclear Power Plants recently developed and promulgated for implementation by NPOC.

I will briefly discuss the nature of the Strategic Plan, its purpose and contents, and show why its framework is a meaningful one for evaluating the future of nuclear reactor technology for commercial power generation. Then, I will focus on four specific elements, known in the Strategic Plan as "building blocks" and explain why Congressional action is needed to keep our American-born nuclear technology from being surrendered to foreign countries. These four building blocks are: design certification, first-of-a-kind engineering, siting for ALWR plants and licensing reform.

THE NPOC STRATEGIC PLAN

No longer is the question of the future of nuclear power an abstract one; the debate period has been fruitful and positive, but action is now required. In the past, some have declared that fission plants should be abandoned, claiming that nuclear power is unsafe. This claim has proven to be false; consensus science and public opinion are to the contrary. Throughout the halls of Congress, the corridors of industry, and in universities, laboratories, town halls, and in the homes of many Americans, past fears and superstitions about nuclear power are steadily giving way to the advancement of scientific fact, prudent engineering, technological achievement and safe nuclear power plant operating records. Every day more Americans realize what nuclear power plant operators have always known: nuclear power is safe, nuclear power is economical, and nuclear power is environmentally advantageous.

However, it is generally recognized that the present legal framework governing licensing procedures is not conducive to private-sector support of renewed nuclear energy growth in the United States. Historically, this outdated framework has contributed to construction delays, unnecessary cost escalations, and an unstable regulatory climate. In the most extreme cases, completed plants have been prevented from operating. Thus, until Congress provides greater stability and predictability in the legal framework, utilities and the financial community will not commit to the major investment needed to build new nuclear power plants.

Based on such awareness, and the conviction that the reemergence of nuclear energy is essential for meeting the ever-increasing electric energy requirements of the nation, NPOC formed an Ad Hoc committee to coordinate the task of identifying the necessary prerequisites to accomplish this objective. That committee developed a strategic plan with a clearly defined goal; being able to order new nuclear power plants by the mid-1990s, which could be built and operating to meet electricity demand by the turn of the century. A copy of the summary of the Strategic Plan is attached as my Exhibit 1.

Under NPOC's leadership, all major segments of the industry -- electric utilities, design and engineering firms, research institutions, and regulatory affairs organizations, are working together to identify approaches to the institutional, technical and financial issues affecting the planning and construction of future nuclear power plants. This comprehensive integrated plan:

- identifies the significant conditions which must be met for advanced nuclear energy plants to be built with confidence;
- assigns responsibilities to industry organizations for developing and implementing plans to achieve these conditions; and

- fosters joint and coordinated efforts between government and industry to develop the framework for building new nuclear energy plants.

NPOC's Strategic Plan is a detailed blueprint that encompasses fourteen building blocks, each with specific goals and milestones, to promote an environment for new plant orders.

These building blocks are divided into four categories:

I. Prerequisites from Ongoing Programs

There is a need to increase confidence in nuclear power through improved performance. That need is being addressed in ongoing programs, but progress in those programs must be monitored and coordinated since they influence the prospects for success of the overall plan. Four of the building blocks comprise these prerequisite conditions and have the following individual goals:

CURRENT NUCLEAR PLANT PERFORMANCE

Maintain and improve the high safety and reliability performance of operating plants.

LOW-LEVEL RADIOACTIVE WASTE

Assure availability of low-level nuclear plant waste disposal capacity.

HIGH-LEVEL RADIOACTIVE WASTE

Achieve progress with the high-level waste (spent fuel) disposal system that includes a permanent repository and a temporary monitored retrievable storage (MRS) facility.

ADEQUATE, ECONOMIC FUEL SUPPLY

Assure a continuing stable and economic supply of nuclear fuel.

II. Generic Safety/Environmental Regulation and Industry Standards

Building new nuclear plants requires a stable and predictable safety and environmental regulatory process. The primary need is for a combined construction and operating license. Companies must be able to obtain a license to operate the plant at the same time they obtain a license to construct it. The design certifications and combined licenses must be based on standardized regulatory requirements that will not vary or be changed throughout the life of the design certification or the life of the plant, unless stringent backfit criteria are applied. They must also include Inspections, Tests, Analyses, and Acceptance Criteria, including a "sign as you go" process, which will assure the regulator and the owner that the plant is built in accordance with the licensing requirements established during the combined license review and hearings. The goals of these building blocks are:

PREDICTABLE LICENSING AND STABLE REGULATION

Assure that regulatory processes are in place for predictable licensing, including site approval and design certification, for construction, start-up and commencement of full-power operation of new plants.

ALWR UTILITY REQUIREMENTS

Complete ALWR Utility Requirements Document and obtain NRC approval.

III. Project-Specific Activities

The building blocks in this group are the technical activities of design, development and testing, site qualification, regulatory review, and project cost and schedule estimates. These provide the construction and operational specifications for the plant. The first major design and testing activity is that required to obtain design certification from the NRC. The second design step, called first-of-a-kind engineering, is the additional design and confirmatory testing necessary to produce the construction drawings, equipment specifications, construction and operational procedures, and final cost and schedule estimates to permit start of construction. The industry's fundamental objective in these design processes is to achieve standardization -- a family (or families) of plants that are essentially the same.

The goals of the four building blocks in this category are:

NRC DESIGN CERTIFICATION

Obtain NRC certification of ALWR designs.

SITING

Obtain NRC approval of suitable site(s) for new nuclear plants either through early site permitting or through submission of an application for a combined construction and operating license.

FIRST-OF-A-KIND ENGINEERING

Complete engineering on certified designs in sufficient detail to define firm cost estimates and prepare for construction of ALWR plants.

ENHANCED STANDARDIZATION BEYOND DESIGN

Develop enhanced standardization concepts and cooperative arrangements as a means to increase the predictability of construction cost and schedules, and to improve operational reliability and cost.

IV. Institutional Steps

A strong element of the plan, which is key to the success of these last four building blocks, is the broad communication of the results of the previous building blocks to those outside the nuclear industry. This will provide awareness of the benefits of the country's investment in nuclear power, which include major improvements in current plant operations, future nuclear power plant designs (particularly their safety features), and the effectiveness of safety and environmental regulation. These final four building blocks have the following goals:

ENHANCED PUBLIC ACCEPTANCE

Achieve broad U.S. public acceptance of nuclear power.

Achieve local public attitudes, at potential plant sites, which are conducive to plant construction and operation.

CLARIFICATION OF OWNERSHIP AND FINANCING

Develop a structure for financing, ownership, and operation of nuclear plants which reasonably compensates investors/lenders for associated risks.

STATE ECONOMIC REGULATORY ISSUES

Achieve support by state regulatory agencies for predictable and stable handling of permitting and financial matters.

ENHANCED GOVERNMENTAL SUPPORT

Enhance governmental support for the necessary institutional framework, including laws, regulations and programs, that encourage the construction and operation of new nuclear plants.

At Southern Nuclear we are involved, in varying degrees, in the tasks necessary to achieve each one of the fourteen building blocks. We believe that successful completion of each block is an integral part to preserving the nuclear option for future baseload generation purposes. Each component of the strategic plan contributes, synergistically, to the common goal; establishing a framework which would allow an investor-owned utility to place a new nuclear power plant order by the mid-1990s. For the Southern electric system, preserving the nuclear option will provide the opportunity to evaluate diverse fuel choices for satisfying future growth in baseload demand. Moreover, it will also provide the appropriate framework to support a reasonable business decision making the necessary financial commitments to apply for a combined license and to place orders for a site-specific design and for long lead-time equipment. After obtaining the option, it must be adequately attractive to serve the economic needs of our customers.

Four of the blocks, however, are of particular significance to this Subcommittee because their success depends on Congressional action. These are the building blocks related to licensing reform, designs for NRC certification, first-of-a-kind engineering, and siting -- all involving advanced light water reactor plants. To make adequate progress with the NPOC plan, legislation is needed that achieves licensing reforms to streamline the current process and approves DOE's FY-1992 budget request for its advanced light water reactor programs. Without such legislation, an important opportunity to realize the proven benefits of nuclear power and the promise of past research and development will be in jeopardy.

SOUTHERN COMPANY'S NEED FOR FUTURE BASELOAD GENERATION

Utility planners are presently making decisions about their generation mix for the year 2000. A typical lead time for a baseload coal plant is 6-8 years to complete the requisite environmental studies, receive necessary permits, negotiate fuel procurement contracts and construct the plant. It is projected that a mid-sized, passive reactor will require a similar planning horizon once an appropriate licensing process is established. Without Congressional action now, no consideration will be given to nuclear power as a resource available to meet our nation's projected baseload generation needs, which are a mere nine years away. This means that an opportunity for fuel diversity, an important concept in least-cost generation planning, will be lost.

For The Southern Company, the need to preserve the nuclear option is very real. Our 1991 integrated resource plan projects an initial requirement for 800 megawatts (MW) of baseload generation soon after the turn of the century, with other additions to follow in succeeding years. This baseload generation is comparable with the amount of electricity used each month by 500,000 homes. The Southern Company's projected need is based on a conservative annual growth rate in this decade of 2.6%. In 1990, as shown by my Exhibit 2, The Southern Company operated 5,400 MW of nuclear power, which was 15% of the generation it operated. However, 36,500 gigawatt hours (GWH), or 23% of the energy mix from all units it operated, came from the three nuclear plants. (Exhibit 3). By contrast, only 7% of the generation capacity was fueled by oil and gas and it accounted for only 1% of the energy. By 2002, we project that 24.3% of The Southern Company's generation capacity will be fueled by oil and gas, principally for intermediate and peak load purposes. (Exhibit 4). Nonetheless, this increased demand for these fuels will exist at a time when some other utility systems, if denied the nuclear option, will be forced to consider oil and gas for baseload generation purposes. Such increased demand will undoubtedly have the effect of increasing our nation's dependence on oil and gas, which is not in our collective long-term best interest. I should add here that these projections include the effect of active demand-side options such as interruptible service contracts or tariffs with certain customers and utilization of stand-by generation capabilities of various commercial and industrial customers, as well as affirmative support for conservation measures.

The facts are clear. Without broad based support, including Congressional support, the nuclear option will be surrendered to the French, Japanese and other countries. The Southern Company, like many other investor-owned utilities, will be limited to choosing either coal or oil and gas for the vast majority of its future generation needs. While natural gas may have an important role to play in units constructed to meet intermediate and peak load projections, current economic forecasts do not favor this fuel for baseload generation for our system. From our perspective, reliance solely on coal as the only fuel available for baseload generation is poor planning, shortsighted and will inevitably lead to troublesome times in the supply of electric power to our customers.

DESIGN CERTIFICATION, FIRST-OF-A-KIND ENGINEERING, SITING, AND THE IMPORTANCE OF DOE PARTICIPATION

Through my role as a member of the Utility Steering Committee for the Advanced Light Water Reactor program, I have first-hand knowledge of our industry's requirements for ALWR design and the design work being done for certification. Continuation of the partial funding being proposed by DOE for this design work is vital to the timely achievement of the NPOC plan goal.

Participation by DOE in the first-of-a-kind engineering program is also vital for meeting the NPOC plan goal. First-of-a-kind engineering is the detailed design beyond that needed by the NRC for design certification and which is not site-specific. It can be used over and over again for each new plant in a family of standardized plants. The use of such standardization reduces costs, enhances safety, and is a prerequisite for standardization beyond design. Generally, the greater the degree of standardization among a plant in a standardized family of plants, the greater are the benefits. The amount of funding in the DOE-proposed budget should be increased to allow parallel pursuit of more than one ALWR design.

The participation of DOE in the siting process is also needed. The challenges for site certification are similar to those for design certification. It has been a very long time since a site has been approved in the licensing process. There are many site designs and site-related matters to be pursued.

U.S. utilities have for several years been leading an industry-wide effort to establish a technical foundation for the design of the next generation of light water reactors. The utilities' Advanced Light Water Reactor (ALWR) program, managed by the Electric Power Research Institute (EPRI), has been closely coordinated with and supported by the Department of Energy's Light Water Reactor (LWR) Program. In our opinion, the most significant result of this effort is passive plant technology.

At Southern Nuclear, we believe that the passive ALWR technology will be the dominant nuclear energy technology for the next increment of nuclear capacity ordered in the United States. Accordingly, we recommend that Congress increase its support for

DOE's participation in programs that will advance the timetable for certification of this technology.

Southern Nuclear is principally interested in mid-sized, passive advanced light water reactors because they use simplified engineering designs, lower construction costs, and improved power plant operations and maintenance. Because they feature passive safety systems, which minimizes the need for an operator to intervene in the event of an accident or equipment breakdown, and because they utilize gravity and certain physical properties of materials to remove heat automatically from the reactor core in an emergency, Southern Nuclear believes that they are more likely to receive broad-based public acceptance. Of course, a Westinghouse Model AP600 or GE SBWR passive plant requires a smaller financial commitment and offers more potential to match incremental supply with growth in demand, since a 600 MW plant is much easier for us to fit into a load growth curve than is a much larger and more costly plant. Naturally, we are aware that other utilities may prefer the larger, evolutionary reactors for load growth, siting considerations and other understandable reasons. While the passive ALWR plants fit best in our generation plan, we are nonetheless supportive of the evolutionary design technology.

Accordingly, we support DOE's FY-1992 budget request, in which the DOE Nuclear Energy Office has requested a total of $112 million for civilian nuclear activities, $62.5 million for LWR's and $49.5 million for advanced reactor R&D. We support a commitment by Congress to fund DOE's continued support of design certification until its completion and to fund DOE's participation in first-of-a-kind engineering. In the past, DOE has participated in research efforts for clean coal technology, solar and wind power and other renewable sources of energy. The Southern Company has participated in much of this research. Nuclear power's current contribution to our nation's electric energy requirement and bright promise for the future is no less deserving of substantial R&D support. To us, nuclear power's record of success justifies the full $112 million for the specific programs requested by DOE.

From our perspective, DOE's passive LWR research and development participation makes an important contribution to commercial reactor standardization and Congress should increase its financial support for this worthwhile effort. Once commercial reactor standardization occurs, the competitive market is the best place to determine which manufacturer receives the first order.

THE NEED FOR LICENSING REFORM

This Subcommittee is knowledgeable and well-versed in the problems existing with the current nuclear licensing process. Uncertain regulatory requirements, leading to customized design-as-you-go nuclear plants, and a two-step licensing process have contributed to vast construction cost overruns and the subsequent disallowance for ratemaking purposes of billions of dollars of investment. What will be stressed here are two guiding principles upon which any new nuclear power legislation must be based and Southern Nuclear's perception of how best to articulate clearly these principles in any legislation.

Regulatory stability and fairness are the bedrock of the future of nuclear power. Without them, neither the investor, whose capital must be attracted back to the industry, nor the public, who must believe that the proposed plant design is safe, economical and that plant operations will not endanger health and safety, will support a new nuclear plant construction project. A certified, standardized design for a family of nuclear power plants, in itself, will promote stability by confirming the scope of the building effort and the necessary economic commitment to support it. Fairness in the licensing process is important for the opportunity it presents to resolve safety issues in an open forum and accord any decision its proper finality. Both the certified, standardized design and a fair licensing process are needed to satisfy future utility investors that their capital will not be lost or diminished in value and to satisfy the public that the plant is safe to operate.

A principal component of any decision to commit to the major capital expenditure required for baseload generation is a concern over whether the investor will receive a fair rate of return on the invested capital. Many utility investors are portfolio managers, IRAs, retirement plans and similar capital sources whose managers weigh carefully the risk/reward components of every investment decision. When they loan money to the future, which is what they do by purchasing securities issued to fund construction of a new nuclear plant, a key element affecting the return on capital they require will be an evaluation of the investment risk. If instability and uncertainty are associated with the construction project and its licensing, then the investor perceives more risk and requires a concomitant higher interest rate. The converse is also true; more stability equals less uncertainty, a reduced risk and, accordingly, savings of millions of dollars in interest costs which need not be borne by a utility's ratepayers.

Given the current regulatory instability and unfairness, even if a utility were willing to accept the risk of ordering a new nuclear plant, investors may very well be unwilling to accept the risk associated with financing the effort. For now, the opportunity to order a new nuclear power plant is in a self-sustaining failure mode: the prohibitive risk of uncertain construction requirements begets a prohibitive financial risk to the investor, paralyzing the nuclear option and forcing reliance solely on fossil fuels.

It is poor public policy indeed to tolerate a statutory framework that produces such stagnation. No one gains when uncertainty, instability and delay prevail. All of us suffer loss in one form or another. By insuring a stable, fair and predictable reactor design and licensing environment, Congress will promote an objective that benefits all Americans -- from those who receive the energy from the generation unit, to those whose pension funds and retirement income are free from any artificial and unneeded investment risk. Promotion of regulatory stability must be a guiding light in any legislative effort.

Of equal concern is public perception of fairness. For a utility to recover fully its cost of service associated with its obligation to serve its customers, the public, acting through their state regulators, must believe that the process of determining the amount of investment, and its recovery, comport with traditional American notions of fair play and even-handedness. In nuclear power, this means that the public should have a significant opportunity, early in the licensing process when its participation can be meaningful and constructive, to satisfy itself that health and safety are not being compromised and that the budget of the utility for building the proposed plant is realistic. Fairness also means that once the necessary decisions are made to establish the licensing basis for a new plant, they should be respected, accorded the weight of other regulatory decisions, and not subjected again to an adversarial hearing process. Issues concerning construction, emergency planning and operation of the plant, once resolved, should not be re-opened absent compelling, concrete evidence of safety significance.

One additional point should be made as providing an incentive for Congress to act now. In November, 1990, in NIRS v. NRC, 918 F.2d 189 (D.C. Cir. 1990), the District of Columbia Circuit Court of Appeals ruled that the Atomic Energy Act requires a pre-operational hearing of potentially broad scope before a full power operating license can be granted. This Committee can be assured that, from the perspective of an investor-owned utility, no new nuclear power plant order will be placed as long as the current licensing procedures exist. As Sherwood H. Smith, Jr., Chairman, President and Chief Executive Officer of Carolina Power and Light Company, observed in his testimony last year before the Senate Subcommittee on Nuclear Regulation, the possibility for a pre-operational hearing, on the critical path, of indefinite duration is a tremendous deterrent to any utility considering ordering an advanced reactor. Past experience vividly demonstrates that pre-operational hearings can be used for the purpose of delaying plant operations, thereby holding hostage billions of dollars of invested capital, rather than for insuring conformance with the license or the requirements of the Atomic Energy Act. Because this recent court decision suggests strongly that an adversarial, pre-operational hearing of potentially broad scope may remain on the critical path of any new nuclear plant, legislation is necessary now to achieve the proper balance in the licensing process.

Only then will America have the potential to declare its independence from dependence on fossil fuel as a sole source for future baseload generation.

In order to assure regulatory stability and provide a fair opportunity for all interested parties to air their concerns about a proposed plant, Southern Nuclear supports a full adjudicatory hearing prior to issuance of a combined license. The purpose of that hearing should be to address and resolve design, siting, and emergency preparedness issues, together with establishing the inspections, tests, analyses and acceptance criteria necessary to comply with the Atomic Energy Act.

Our preference is for legislation that amends Section 185 of the Atomic Energy Act by adding a section pertaining to combined operating licenses. Such an amendment would articulate that a combined operating license will contain the necessary acceptance criteria to assure compliance with all aspects of the Atomic Energy Act, including the requirements of Section 103 and the current Section 185. We believe that by linking the acceptance criteria to the findings required by the Atomic Energy Act, the NRC can then design inspections, tests, and analyses which will provide reasonable assurance that the plant can operate safely both as a technical matter and within the legal framework of the Atomic Energy Act. Then, our recommended legislation would specify that satisfaction of the acceptance criteria and subsequent receipt of an authorization to operate under Section 185 would not be another grant of a "license" requiring a second adjudicatory hearing under Section 189a. A very good start towards achieving this legislative objective has been made by both the National Energy Strategy and Congressman Clements' Bill, the Nuclear Powerplant Standardization and Licensing Reform Act of 1991.

Importantly, we do not ask Congress to deny hearing opportunities for any significant new safety information, nor do we ask it to eliminate altogether the possibility of a pre-operational hearing. Significant new safety information developed during the construction of a new nuclear power plant can be raised through current NRC procedures by filing a petition to modify, suspend or revoke the combined operating license. This is the identical process that would now be followed if significant new safety information is discovered that challenges the licensing basis of an existing plant. It is not logical that a process deemed acceptable for currently operating plants should be cast aside for those constructed pursuant to a combined operating license. After all, a combined operating license and its acceptance criteria will already have been subjected to rigorous examination in a full adjudicatory process prior to its issuance.

Another possibility for a hearing is a challenge by an interested person to the propriety of an NRC finding that the plant has met a particular acceptance criterion. We believe that a hearing should be held on such a challenge only if the complaining party makes out a prima facie case, by substantial, credible evidence, that an acceptance criterion has not been met, that such a failure seriously compromises public health and safety, and that any purported deficiency cannot be resolved without a hearing. Because such a showing would in essence be a challenge to the results of a prior NRC determination reached through the process of inspections, tests and analysis, the challenger should bear the full burden of proof on the issue. Of course, since the utility had already complied with the mandated inspections, tests and analysis, then its investment should not be held hostage by placing such a hearing on the critical path. The plant should be authorized to operate notwithstanding a hearing request. The NRC should have the flexibility to determine whether such a hearing should be adjudicatory or non-adjudicatory, depending on the issue raised and the desire of other interested parties to present testimony and to examine or cross-examine witnesses. Of course, if it is proven that an acceptance criterion has not been met, then the NRC can fashion an appropriate remedy.

Finally, another way of insuring stability and fairness in the process is to provide for amendments to the combined operating license in the same manner available for currently issued operating licenses. An amendment involving no significant hazards consideration should be made immediately effective notwithstanding a request for hearing. An amendment involving a significant hazards consideration can be the subject of hearings in the same manner as the initial combined operating license.

Because our comments regarding proposed amendments to the Atomic Energy Act rely, wherever possible, on existing licensing procedures associated with operating licenses for the nation's 112 commercial nuclear power reactors, then we believe there will be wide acceptance in both the public and the nuclear industry of this process. It fairly balances the interest of the public by insuring that the acceptance criteria relate directly to the findings mandated by the Atomic Energy Act, while simultaneously assuring a utility, its investors and state regulatory commission that, if the acceptance criteria are satisfied, no artificial, procedural delay tactics can prevent plant operations. Instead, operation of the plant can proceed on schedule.

CONCLUSION

This concludes my testimony. Again, let me say that it is an honor for me to have this opportunity to present testimony to this Subcommittee. We at Southern Nuclear remain vitally interested in the legislative process and look forward to a bill that will protect our nation's electric energy future by promoting reactor standardization and licensing reform.

EXHIBIT 1

STRATEGIC PLAN FOR BUILDING NEW NUCLEAR POWER PLANTS

NUCLEAR
POWER
OVERSIGHT
COMMITTEE

STRATEGIC PLAN
FOR BUILDING
NEW NUCLEAR POWER PLANTS

NUCLEAR POWER
OVERSIGHT COMMITTEE

November 1990

NUCLEAR POWER OVERSIGHT COMMITTEE

Sherwood H. Smith, Jr., Chairman
Chairman, President and CEO, Carolina Power & Light Company

J. Phillip Bayne
President and COO, New York Power Authority
Representing American Public Power Association
Chairman, Ad Hoc Committee for NPOC's Strategic Plan

Shelby T. Brewer
President, ABB-Combustion Engineering Nuclear Power

Joseph M. Farley
Executive Vice President, Nuclear, The Southern Company
Chairman of the Board, American Nuclear Energy Council

J. S. Farrington
Chairman and CEO, Texas Utilities Company
Chairman of the Board, U.S. Council for Energy Awareness

E. James Ferland
President, CEO, and Chairman of the Board, Public Service Electric & Gas Company
Chairman of the Board, Electric Power Research Institute

William S. Lee
Chairman and CEO, Duke Power Company

Walter J. McCarthy, Jr.
Past Chairman and CEO, The Detroit Edison Company
Chairman of the Board, Institute of Nuclear Power Operations

Eugene R. McGrath
Chairman and CEO, Consolidated Edison Company of New York
Chairman of the Board, Nuclear Management and Resources Council

James J. O'Connor, Jr.
Chairman and CEO, Commonwealth Edison Company
Representing Edison Electric Institute

Joseph F. Paquette, Jr.
Chairman and CEO, Philadelphia Electric Company

F. F. (Bud) Stacey, Jr.
President and CEO, Oglethorpe Power Corporation
Representing National Rural Electric Cooperative Association

Bertram Wolfe
Vice President and General Manager, GE Nuclear Energy

John B. Yasinsky
Executive Vice President, Power Systems, Westinghouse Electric Corporation

Adrian Zaccaria
President, Bechtel Power Corporation

MESSAGE FROM THE CHAIRMAN

The United States faces two serious energy problems. The first involves this country's dangerous, growing dependence on imported oil, which now represents more than half of U.S. oil consumption. The second is ensuring the adequate, reliable, affordable supplies of electricity over the long term as needed to sustain U.S. economic growth and a rising standard of living for all Americans.

These two problems are closely related. Between 1973 and 1989, virtually all new electric supply came from coal-fired and nuclear energy plants. These plants made possible a dramatic reduction in the amount of oil burned for electricity production. Today, however, only a handful of new coal and nuclear plants are still being built--far fewer than needed to meet projected growth in electricity demand. Many electric utilities are reluctant to consider ordering new nuclear plants because of the many regulatory and financial uncertainties and risks they have experienced over the last 10 to 15 years. As a result, some utilities are turning to existing oil-fired plants and using more imported oil.

Given America's need for adequate electricity, energy security and a clean environment, we must reverse this trend and renew our commitment to secure, plentiful, domestic sources of electricity like nuclear energy.

A Position Paper prepared by the Nuclear Power Oversight Committee* reviews the benefits of nuclear energy (including its role in displacing imported oil and protecting our environment), discusses the negative consequences of not building new nuclear plants, and reviews the obstacles that stand in the way of new nuclear plant orders.

Providing the new electric supply that will be needed in the 1990s is a complex undertaking. It will require the balancing of many risks, many uncertainties and many competing interests. No single fuel can satisfy all circumstances. Fuel diversity is one of the great strengths of the U.S. electric supply system, and nuclear energy has a key role to play.

The electric utility industry wants to include nuclear energy in its planning for new capacity. Specifically, the industry has set a goal of ordering and building new nuclear plants within the next several years; so that they may be on-line by the end of the decade or soon thereafter.

---

* A Perfect Match: Nuclear Energy and The National Energy Strategy, Nuclear Power Oversight Committee, November 1990. This is an update of an earlier NPOC Position Paper, Nuclear Energy For the Future: What We Must Do, published in January 1989.

Many questions must be answered and many issues resolved before electric utilities will be able to order new nuclear capacity. This Strategic Plan, developed by an Ad Hoc Committee created by the Nuclear Power Oversight Committee, creates a framework within which new nuclear plants may be built.

This plan is an expression of the nuclear energy industry's serious intent to create the necessary conditions for new nuclear plant construction and operation. The industry has assembled a comprehensive, integrated list of all the actions that must be taken before new plants will be built. Perhaps more important, it assigns responsibility for managing the various issues, and sets timetables and milestones against which we can measure progress.

All elements of our society--government, industry, academia, environmental groups, political organizations and others--must work together to ensure the United States increases its reliance on secure, domestic fuel sources. Nuclear energy gives America the power of independence. Working together, we can ensure a major role for nuclear energy in this country's energy strategy, and a bright future for America in the years to come. With this Strategic Plan, the nuclear energy industry makes an earnest commitment to do its part.

Sherwood H. Smith, Jr.

Chairman
Nuclear Power Oversight Committee
and
Chairman, President, and Chief Executive Officer
Carolina Power and Light Company

SECTION I

EXECUTIVE SUMMARY

AD HOC COMMITTEE FOR NPOC STRATEGIC PLAN

J. Phillip Bayne, Chairman
President and COO, New York Power Authority

Shelby T. Brewer
President, ABB-Combustion Engineering Nuclear Power

Edward M. Davis
President, American Nuclear Energy Council

Harold B. Finger
President and CEO, U.S. Council for Energy Awareness

Edwin E. Kintner
Executive Vice President (Ret.), GPU Nuclear
Chairman, ALWR Utility Steering Committee

Byron Lee, Jr.
President and CEO, Nuclear Management and Resources Council

R. P. (Pat) McDonald
Executive Vice President, Alabama Power Company
Executive Vice President, Georgia Power Company

Ted C. McMeekin
Vice President, Design Engineering Dept., Duke Power Company

Loring Mills
Vice President, Nuclear Activities, Edison Electric Institute

Zack T. Pate
President, Institute of Nuclear Power Operations

Charles W. Pryor, Jr.
Vice President and General Manager, B & W Nuclear Technologies

John J. Taylor
Vice President, Nuclear Power, Electric Power Research Institute

Michael Wallace
Vice President Nuclear, PWR Operations, Commonwealth Edison Company

Bertram Wolfe
Vice President and General Manager, GE Nuclear Energy

John B. Yasinsky
Executive Vice President, Power Systems, Westinghouse Electric Corporation

STRATEGIC PLAN FOR BUILDING NEW NUCLEAR POWER PLANTS

SECTION I: EXECUTIVE SUMMARY

THE NEED FOR A PLAN

The Nuclear Power Oversight Committee (NPOC) has developed a Strategic Plan with the goal of being able to order new nuclear power plants by the mid-1990s, which could be built and operating to meet electricity demand by the turn of the century. Section II of this report presents an outline of the plan. Section III provides detailed action plans. The Strategic Plan, when successfully executed, provides an institutional framework within which future advanced nuclear plants could be built with confidence.

NPOC has developed this plan because it is convinced that the United States will need additional nuclear power plants in the 1990s and beyond. There is increased urgency to meet this need because:

- The projected shortfall in baseload electric generation capacity in the mid-1990s is becoming more certain.
- New requirements for air pollution controls on coal plants, such as those identified in the new amendments to the Clean Air Act, will increase the cost and regulatory uncertainty of electricity generation from coal.
- Although today's operating nuclear plants have greatly reduced the use of imported oil in electricity generation, imported oil usage is growing again in the electric sector. New nuclear plants are needed to reverse this unfortunate trend.
- Increased concern about the possible long-term effects of greenhouse gas emissions calls for greater priority in developing and utilizing electric generation processes that do not produce greenhouse gases.

In its recent Position Paper[*], an update of an earlier NPOC Position Paper[**], NPOC substantiates these reasons for urgency as well as the important benefits and outstanding record of today's 112 U.S. nuclear plants. The paper also summarizes the industry's major effort to improve the operations of present plants, and identifies the programs underway to design even safer, more reliable, and more economic standardized nuclear plants for the future. The extensive operating experience with today's light water reactors (LWRs), and the promise shown in recent technical developments, leads the industry to the conclusion that the next nuclear plants ordered in the United States will be advanced light water reactors (ALWRs). Two types are under development: units of large output (1300 MWe) called "evolutionary" ALWRs and units of mid-size output (600 MWe) called "passive" ALWRs. (The term "passive" describes the emergency cooling features, which depend more on natural processes such as gravity than on powered equipment such as pumps.) Both approaches rely on proven technology. In addition to the technical design issues, federal and state regulatory uncertainties must be reduced so that the financial risks of nuclear plant construction and operation are reasonable.

---

[*] A Perfect Match: Nuclear Energy and the National Energy Strategy, November 1990, published by U.S. Council for Energy Awareness, 1776 I Street NW, Suite 400, Washington, DC 20006

[**] Nuclear Energy for the Future--What we Must Do, January 1989.

Significant progress toward resolving the issues identified in this plan is needed before firm commitments to order more nuclear plants can be expected. It takes many years to license and build the nuclear power plants that will contribute to the needed electric generation capacity in the future. That is why it is important to start planning now.

This Strategic Plan, then, outlines an integrated effort to address the range of institutional and technical issues on which significant progress must be achieved to make nuclear power attractive for the 1990s.

THE CONTENT OF THE PLAN

The plan:

- identifies all the significant enabling conditions (technical/industrial, regulatory, environmental, financial, legislative/legal, organizational, political, and public acceptance) which must be met to achieve the goal;
- assigns lead and supporting responsibilities to the appropriate existing organizations or standing committees in the industry to detail and implement an action plan for achieving each condition;
- fosters joint and coordinated efforts between government and industry which would enhance implementation of the strategies and provide for sharing resource requirements.

Fourteen enabling conditions, or "building blocks," have been defined, each of which uniquely contributes to the complete structure. The "building blocks" are outlined in Figure I-1, which shows the title and lead industry responsibilities, and are grouped into four categories:

Figure I-1: BUILDING BLOCK SUMMARY

PREREQUISITES FROM ONGOING PROGRAMS

Current Nuclear Plant Performance
(Utilities)

Low-Level Radioactive Waste
(EEI-ACORD)

High-Level Radioactive Waste
(EEI-ACORD)

Adequate, Economic Fuel Supply
(EEI)

GENERIC SAFETY/ENVIRONMENTAL REGULATION & INDUSTRY STANDARDS

Predictable Licensing & Stable Regulation
(NUMARC)

ALWR Utility Requirements
(EPRI-USC)

PROJECT-SPECIFIC ACTIVITIES

NRC Design Certification
(Plant Designers)

Siting
(EPRI-USC/NUMARC)

First-of-a-Kind Engineering
(EPRI-USC)

Enhanced Standardization Beyond Design
(NUMARC;

INSTITUTIONAL STEPS

Enhanced Public Acceptance
(USCEA)

Clarification of Ownership & Financing
(EEI)

State Economic Regulatory Issues
(EEI)

Enhanced Governmental Support
(ANEC)

A. Prerequisites From Ongoing Programs

There is a need to increase confidence in nuclear power through improved performance. That need is being addressed in ongoing programs, but progress in those programs must be monitored and coordinated since they influence the prospects for success of the overall plan. Four of the building blocks comprise these prerequisite conditions and have the following individual goals:

- Maintain and improve the high safety and reliability performance of operating plants.
- Achieve progress with the high-level waste (spent fuel) disposal system that includes a permanent repository and a temporary monitored retrievable storage facility.
- Assure availability of low-level nuclear plant waste disposal capacity.
- Assure a continuing stable and economic supply of nuclear fuel.

B. Generic Safety/Environmental Regulation and Industry Standards

Construction of new nuclear plants requires a stable and predictable safety and environmental regulatory process. The primary need is for a combined construction and operating license. Companies must be able to obtain a license to operate the plant at the same time they obtain a license to construct it. The Nuclear Regulatory Commission (NRC) issued a new rule on this subject in 1989, titled "Early Site Permits; Standard Design Certifications; and Combined Licenses for Nuclear Power Reactors" (10 CFR 52). In implementing the new rule, the design certifications and combined licenses must be based on standardized regulatory requirements that would not vary or be changed throughout the life of the design certification or the life of the plant, unless stringent backfit criteria were applicable. They must also include Inspections, Tests, Analyses, and Acceptance Criteria, including a "sign as you go" process, which will assure the regulator and the owner that the plant is built in accordance with the licensing requirements established during the combined license review and hearings. Another key task is reconciling regulatory definitions and jurisdiction among the NRC, the Environmental Protection Agency (EPA), and state safety and environmental regulatory agencies. The two goals of this building block are:

- Assure that regulatory processes are in place for predictable licensing, including site approval and design certification, for construction, startup and commencement of full-power operation of new plants.

- Assure that a high-quality, stable regulatory process is in place to assure safety and environmental protection, and to encourage industry self-improvement initiatives, public confidence, and reasonable cost of electricity.

To assure higher confidence in both safety and economic performance, future plants must be designed to incorporate lessons learned over the past 30 years of commercial nuclear power operation. The next generation of plants must also use features that have been proven adequate for safe, reliable, and economic service with respect to operations and maintenance. This should obviate the need for prototype testing prior to commercial usage. The building block to address these needs is based on the concept of user-defined design requirements and has the following goals:

- Complete ALWR Utility Requirements Document and obtain NRC approval.

- Assure that ALWR designs meet the intent of the ALWR Utility Requirements Document.

C. Project-Specific Activities

The building blocks in this group are the technical activities of design, development and testing, site qualification, regulatory review, and project cost and schedule estimates. These provide the construction and operational specifications for the plant. The first major design and testing activity is that required to obtain design certification from the NRC. The second design step, called first-of-a-kind engineering, is the additional design and confirmatory testing necessary to produce the construction drawings, equipment specifications, construction and operational procedures, and final cost and schedule estimates to permit start of construction. Selection, qualification, and licensing of suitable plant sites must proceed in parallel with these design activities and the results factored into the first-of-a-kind engineering processes.

The industry's fundamental objective in these design processes is to achieve standardization--a family (or families) of plants that are essentially the same. The French and Canadian experience in nuclear power has clearly shown that major economies can be achieved through standardization. It eliminates duplication of detailed design and licensing from plant to plant, and provides for a "learning curve" in construction and operation from plant to plant. The definition and implementation of design standardization is a key milestone in the "Predictable Licensing" and "First-of-a-Kind Engineering" building blocks and impacts many other building blocks. In addition, the plan provides for enhanced standardization beyond design to extend the full benefits of standardization to the construction and operating phases, and to assure that individual plants are not customized through uncoordinated changes by plant owners after operation commences.

The goals of the four building blocks in this category are:

- Obtain NRC certification of ALWR designs.
- Obtain NRC approval of suitable site(s) for new nuclear plants, either through early site permitting or through submission of an application for a combined construction and operating license and NRC approval to build and operate the plant to a certified design under its standardization rule.
- Complete engineering on certified designs in sufficient detail to define firm cost estimates and prepare for construction of ALWR plants.
- Ensure that an institutional infrastructure is in place to provide resources and manage completion of detailed design.
- Define the process to achieve standardization in first-of-a-kind engineering.
- Develop enhanced standardization concepts and cooperative arrangements as a means to increase the predictability of construction cost and schedules, and to improve operational reliability and cost.

D. Institutional Steps

The final four building blocks move from the relatively "narrow" world of the nuclear power industry and its safety and environmental regulators to the "wide" world of financing, rate regulation, public acceptance, and governmental support.

Many lessons have been learned in the "narrow" world which, along with significant innovations, are being incorporated into the first ten building blocks. This Strategic Plan, however, also recognizes the lack of sufficient confidence and support in this "wide" world. The plan addresses this issue in the final four building blocks, which have the following goals:

- Achieve broad U.S. public acceptance of nuclear power, and local public attitudes, at potential plant sites, which are conducive to plant construction and operation.
- Develop a structure for financing, ownership, and operation of nuclear plants which reasonably compensates investors/lenders for associated risks.

- Achieve support by state regulatory agencies for predictable and stable handling of permitting and financial matters.

- Enhance governmental support for the necessary institutional framework, including laws, regulations, and programs, that encourage the construction and operation of new nuclear plants.

A strong element of the plan, which is key to the success of these last four building blocks, is to communicate the results of the previous building blocks broadly outside the industry. This will provide visibility to this "wide" world audience of the benefits of the country's investment in nuclear power; and of the major improvements in current plant operations and in future nuclear power plant designs, particularly their safety features and the effectiveness of their safety and environmental regulation. It will also provide the foundation, through standardization, detailed design and planning, and stable nuclear regulation, on which the confidence of the rate regulators and financial analysts can be built.

IMPLEMENTATION OF THE PLAN

The plan is divided into building blocks that are integrated into an overall plan. Each block has a separate organization as the lead responsible for achieving one or more subordinate goals. Each block also has a series of milestones that will assist in monitoring and managing the project. Blocks are linked together by "tie-ins" to ensure coordination between the diverse organizations and the subordinate projects. This ensures that the schedule is monitored, maintained and that the final goal, a standardized nuclear power plant on-line by the turn of the century, is achieved.

Action plans have been developed for each building block. Each lead organization is responsible for implementing its phase of the plan utilizing its own resources, augmented as required, to achieve the block's goal(s). Each block has a series of supporting organizations assigned to provide input and assistance to the lead organization as required. Significant portions of the plan are well underway. These ongoing efforts include technical and safety regulation activities on present and future plants, and public/political acceptance programs more focused on the present issues in the industry.

The plan also recognizes that success in achieving the goals depends on government actions as well as industry. Where government rather than industry has the basic responsibility and authority over a building block, "primary" or "regulatory" responsibility is given to a government agency, not as an assignment, but to recognize that authority. The "industry lead" organization is assigned responsibility for providing input to the processes in that building block. "Primary" responsibility is also assigned to industry organizations where the eventual implementation requires that one or more industry organizations become involved through a major commitment of funds. In such cases, the "lead industry" organization will handle the building block in the interim.

NPOC established an Ad Hoc Committee early in 1990 to develop this plan. That task has now been accomplished. The Ad Hoc Committee will now coordinate the work of the lead industry organizations on behalf of NPOC. This coordination, and periodic assessments of progress against the plan, will allow adjustments to the plan. The explicit portrayal of "tie-ins" encourages "self-coordination" to minimize overall project management requirements in this formative time frame.

The Ad Hoc Committee is specifically charged to:

- facilitate the coordination of the action plans among those having the lead responsibilities in order to achieve consistency, mutual support, and compatibility among the action plans in a total team effort;
- facilitate the implementation and effectiveness of the Strategic Plan by monitoring and reporting progress on the various action plans and recommending to NPOC changes to the Strategic Plan where appropriate; and
- identify, recommend, and foster the needed government-industry shared efforts.

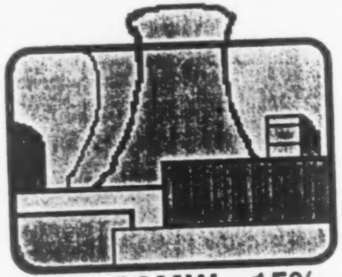
Of course, project management will eventually be needed to carry out the detailed activities as the plan matures. Much of this will have to be provided by the organization(s) that see the need to order new plants. Past experience shows that an outstanding project management team is essential to assure that schedules and budgets are met and to instill confidence in those providing and approving the financial arrangements. The timing for formation of any such organization will presumably coincide with accomplishment of the second goal of the Ad Hoc Committee, complementary to the first goal to develop the plan itself:

- to secure firm commitments from sponsoring organizations to devote the necessary resources to build and start operating one or more standardized ALWR nuclear plants.

EXHIBIT 2

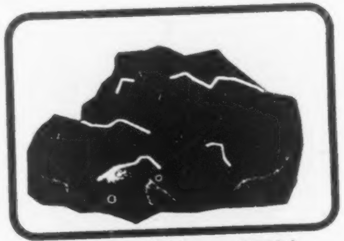
THE SOUTHERN COMPANY GENERATION CAPACITY - 1990

Nuclear



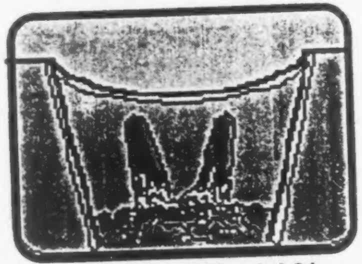
5400MW 15%

Coal



24000MW 67%

Hydro



4100MW 11%

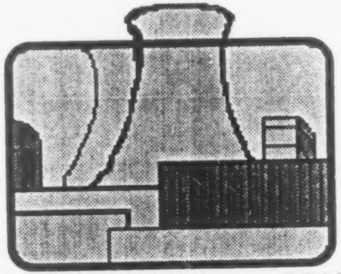
Gas/Oil

2600MW 7%

EXHIBIT 3

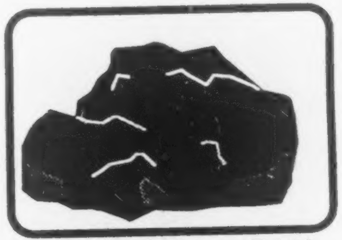
THE SOUTHERN COMPANY GENERATION ENERGY MIX - 1990

Nuclear



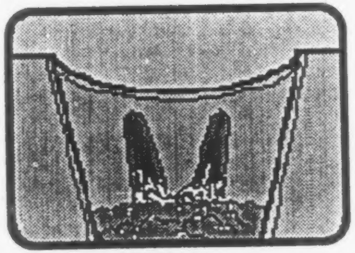
36500GWH 23%

Coal



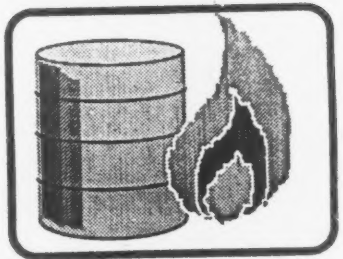
114000GWH 71%

Hydro



8000GWH 5%

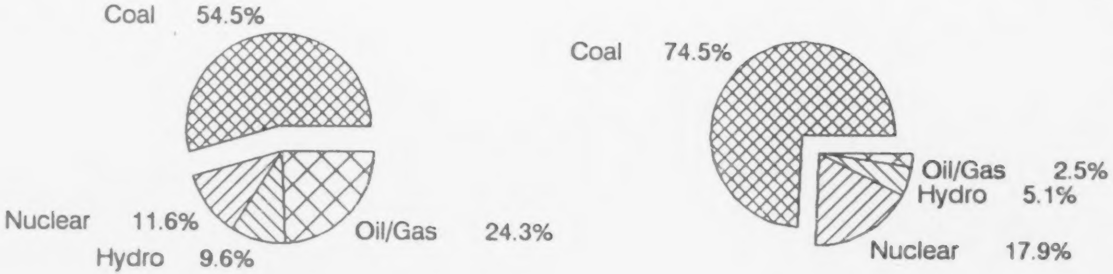
Gas/Oil



2000GWH 1%

EXHIBIT 4

Capacity and Energy Distribution in 2002



Capacity *Energy*

Mrs. **Lloyd.** We're happy to have you with us today. Mr. Morrison.

Mr. **Morrison.** Thank you. As I have listened to you gentlemen through the years, it's interesting to observe some patterns. I have to tell you, I'm very pleased with what I'm hearing this morning. It's also nice to have our engineering design firms bring along a customer, and to hear that you've formed a new fraternity. That is really most pleasing. I hear progress; I hear a strong DOE working relationship. The new organization which, as I've read Mr. McDonald's testimony on through, I find that I think you have really put your finger on the restrictions to our getting on with the nuclear option, as we head toward the close out of this century and into a new one. I'm sorry, Madam Chairman, that Mr. Wolpe wasn't here to listen to this, because this is what he needs to hear, as to a very limited DOE investment that's going to get us some new reactors with some new features that he will like, on order and under construction very quickly.

Mr. McDonald, you sort of answered a question I was going to ask, and I heard from each one of you this first-of-a-kind engineering $20 million investment with design certification, etc. It seems to me that everyone is in tune with that. You're all singing from the same book. So, I sense that the working relationship with DOE is fairly well in place, as I listen to your testimony. If we'll go along with the budget request, then you are satisfied in this next generation of reactors. I'm seeing that, for the record, a number of heads nodding, yes. Mr. Woodson.

Mr. **Woodson.** I wonder if I might translate my nodding head and say that I think you've caught the essence of what's been going on in the industry. We understand that for our society to have a valid option in front of them we must consider nuclear power as part of their energy. All of us who participate in the industry and the regulation in support of the industry are going to have to bring new innovative ideas to the public. We have an opportunity to provide leadership, in every element of this industry. I think what you're seeing is a recognition that with some bold leadership, we can really bring a strong option forward. It's the option that I believe should support the base load energy production in this country.

Mr. **Morrison.** I would agree. Shelby, this is something you have stood for, for years.

Dr. **Brewer.** Yes, and I would like to add something to Mr. Woodson's comment. That is, the industry in the form of NPOC—I sit on the NPOC board—is not looking at a single national design, but rather families of designs. What is sought by the NPOC strategic plan is not one national design and every reactor has to be a replicate of that design. For example, Westinghouse can have a standardized design, General Electric, Combustion Engineering, etc. We are not yet to the degree of nuclear socialism that we need one national design.

Mr. **Morrison.** I presume then, with that design, you will each do your thing as you compete with each other in the marketplace?

Dr. **Brewer.** Correct.

Mr. **Woodson.** The competition will be vigorous, but I think what you'll see coming out of continued support is, in fact, the leadership that allows the community to come back and re-accept nuclear energy as a most important piece of our strategy.

Mr. **Morrison**. I appreciate that. I think some of us on this subcommittee feel like we're involved in a holy war, and we need to rally the troops and have some strategic plans. I sense this is the first really positive indication I have that everyone is working together. I have no further questions, Madam Chairman. I just compliment this element of the industry, because I think they're doing what we absolutely have to do to fulfill, not just a national energy strategy, but the needs of the world for energy in the future.

Mrs. **Lloyd**. It is indeed a bright light, Mr. Morrison. Mr. Barton.

Mr. **Barton**. Thank you, Madam Chairman. I don't know that I can ask but maybe one question, because I wasn't able to hear the panel. I had to meet with some constituents. I do want to welcome Dr. Brewer back. I was a White House fellow in 1981 and 1982 in the Department of Energy when he was the Assistant Secretary for Nuclear Energy. I've got a photograph on my office wall of him and the other assistant secretaries with Secretary Edwards that he signed. He doesn't look a day older today than he did ten years ago in that photograph.

Mrs. **Lloyd**. He'll send you a new picture after that.

[Laughter.]

Mr. **Barton**. I guess the one question I might ask, in general, there has been a lot of concern that our power plants today are too big. I know that these light water reactors—you're designing them in two different groups, the 1,200 to 1,300 megawatt group and the 600 megawatt group. Do you know which of these, do you think, will be the most economic? As an addenda to that, is there any discussion about even a smaller size reactor than the 600 megawatt, or is that about as small as you can go and still be economic? I'll let any of you distinguished gentlemen answer that question.

Dr. **Wolfe**. I'll take the first crack at it, since General Electric has both the large 1,300 megawatt advanced boiling water reactor and the 600 megawatt simplified boiling water reactor. So, we have both. We think there is a market for both of them. Let me answer directly your question. The advantage of the large size reactor is that we think the economics are going to be somewhat better. We're pleased to get the small sized reactor with these simplified features so that we think it can compete. When we do, we think there is going to be a 20 percent or 15 to 20 percent advantage in mills per kilowatt hour from the large plant.

On the other hand, the small plant has flexibility, as Mr. McDonald says. It can meet the load requirements of a utility that wants smaller chunks. It avoids having utility consortiums that in the past have proved difficult. It provides a flexibility that the large plant doesn't have. The large plant, on the other hand, makes use of limited sites. You can argue both ways. When I go down to Georgia Power and talk to Mr. McDonald, it's clear what plant he's interested in. I might say when I go to Chicago, I get a different viewpoint, from the utility customers. I think one can argue both ways. I think, in my view, we are going to see both kinds of plants go. Which dominates in the future is, to some extent, going to depend upon such matters as national policies, where the reactor plants are, etc.

Mr. **Barton**. What about the utility industry, in general, given some of the alternative energy sourcing requirements that we politicians are putting on the industry, is going to smaller and smaller power plants? Is 600 megawatts about as small as you can go for nuclear and still be economically viable?

Dr. **Wolfe**. I'll answer and then I'll let Nat answer. 600 megawatts was, in my view, the smallest size that makes economic sense. It was a size, at least, that we chose where we could get decent economics by simplifying the design. When you get much smaller than that, as I say, the economics already don't compete with the larger ones. When you get much smaller, you do have economic problems. You certainly, technically, can make them as small as you want but, economically, you have difficulties.

Mr. **Woodson**. If I could pick up on Mr. Wolfe's comments, our views in trying to understand the market, have led us to the conclusion that in the range of 600 megawatts, it will be the market size that gives us the volume to allow to bring forward standardization and produce reality out of all these fine words.

In some of your earlier questions to Secretary Young, you were asking on some of the economic terms. In studies that have just been released, we see the generating costs to be under the five cents per kilowatt hour.

Mr. **Barton**. I wish he would have said that.

Mr. **Woodson**. The reason why I go back to that is I see the primary role and mission that all of us are into is producing reliable, low cost, environmentally sound electricity. We can get that out of this product.

When we look at the competitive alternative strategies, another question that you had, we see these cost—cents per kilowatt hour—being clearly fairly straightforwardly ahead of modern coal plants and the evolutionary large nuclear plants. I think natural gas, to the extent the transmission can be generated and that the gas can be delivered to where the plants are needed to be built, is an alternate that we will continue to make our product economically competitive against. When people worry about siting and getting the power out of scare sites, we look at a slightly upscaled version, which would give us the same kilowatts out of the same site area.

The simplification has allowed us to make the economics work at 600 megawatts. When we see ourselves moving much below 600 megawatts, it's not clear that either the economics are there, or the interest in the utility marketplace is there. So, we see 600 up to maybe 900 as a range, but 600 is the one that will, in fact, bring forth the reality of what we have been talking about in standardization.

Mr. **Barton**. I guess my last question, Madam Chairman, I'll direct to——

Dr. **Brewer**. Mr. Barton, could I answer your question, as well? I think the economies of scale certainly work against the smaller plant, the 600 megawatt plant. To make that plant economic with a light water reactor, one has to strip an awful lot of engineered safety equipment off of it, which raises the question if this plant can be licensed with the regulatory framework we now have. Also, on the number of sites, one does not want to waste a licensed site, a suitable site, on a plant that size.

Finally, on what the market is saying, I would ask you to go to Korea and ask one customer to whom I have, in fact, sold four plants to in the past three years. They are large, evolutionary, standardized APWR. That's what the market is saying.

Mr. **Barton**. That's what the market in non-nuclear was saying five or ten years ago. Now it's going the other way. We're going to smaller and smaller generating units. It's just interesting to see where the economics are of this.

Mr. **McDonald**. May I respond to that?

Mr. **Barton**. Yes, sir.

Mr. **McDonald**. I think your question is very good. I think you see some sense of competition from the answers. I think that all four of these plants are outstanding plants. I believe that we've had the international cooperation in all four, and that we are setting a standard, or rather you might say that we are leading the technology worldwide in these four plants. I think that there should be markets for them overseas, as well as domestically.

I previously stated my preference, our company's preference, for 600 megawatts. That's been the last fossil plants, besides, that we brought on the line also. Our load growth, that we anticipate, is about 2.3 percent, somewhere in that range. So, we have to be very careful about what our capital expenditure is, and then what you can get in the rate base. But, I must say that in setting the requirements that the utilities set for the small plants, on costs we set a requirement that it had to be competitive. Thus far, they're given us high assurances that they will meet that and the safety requirements that we've put on them. They are more than meeting those as well.

I think that we are in the midst of a resurgence of the availability of nuclear power. I think we have problems such as high level waste and other things to overcome. But, I feel quite sure that we are going to have the technology ready when it's needed.

Mr. **Barton**. I guess my final question—can I ask one more, Madam Chairman—to Dr. Brewer. I noticed in Assistant Secretary Young's testimony, where he talked about where we're now doing things like gravity flow cooling and trying to simplify the designs. He had a term that previous nuclear plants were complicated engineering. Why in heaven's name didn't we pick up on doing the simple thing first, ten or twenty years ago, instead of just now getting around to it?

Dr. **Brewer**. A lot of this complexity, Mr. Barton, resulted from NRC intervention into a whole collection of heterogeneous designs; as I said before, custom designed and, therefore, custom regulated. A lot of clutter got hung on to these plants during the first nuclear era that cannot be defended on safety grounds. Part of the ALWR, or the central feature of the ALWR program that we're implementing with DOE and with the Korean projects, etc., is to declutter and streamline these designs, without any reduction in safety. In fact, with an improvement of PRA safety.

Mr. **Barton**. Well, I think that's an excellent innovation. You can make that argument not just in the nuclear industry, but go out and look under the hood of your automobile and try to change the spark plugs. They are making up now. I can check the oil in the car that a I bought last year a lot easier than I can in the car that I drive here in Washington, which is ten years old. I mean, America is waking up. We're just doing it ten or fifteen years later, I think, then the rest of the international community.

Dr. **Wolfe**. If I could just add to that, to what Shelby said. I think what we've all done is look to 30 years of experience with light water reactors. I know in my case—but this is also true with Westinghouse and Combustion Engineering—we set up a team that looked worldwide at the boiling water reactors. It took the best features and the simple features to your point from the worldwide experience of 30 years and then developed the advanced boiling water reactor and then the simplified boiling water reactor, based upon the experience that we had before.

The simplification may be like the automobiles. It is based upon the prior experience, the prior mistakes that we're correcting, and the very good experience that we've had, in some cases, which we can incorporate in the new designs.

Mr. **Barton**. I appreciate you folks testifying and look forward to working with you. I yield back to the Vice Chairman.

Mr. **Morrison**. Thank you, Mr. Barton. Thank you to the panel. Our Chairman has been called away to a very important phone call from the Persian Gulf, which I think she was waiting for. We'll reserve the right for her to submit questions to you if she had specific things that she wanted to cover during her opportunity. So, thank you to this panel. We'll proceed then with the second panel, dealing with advanced reactors: Dr. Chuck Till, Associate Director of Engineering, Argonne National Laboratory; Mr. Linden Blue, Vice Chairman of the Board of GA Technologies; and Dr. Alex Zucker, Associate Director, Nuclear Technology, Oak Ridge National Laboratory.

Dr. **Wolfe**. Mr. Morrison, since I talked about reactors, I understand that Mrs. Lloyd was going to ask me to be available for questions.

Mr. **Morrison**. Thank you, Dr. Wolfe. We will add you to this.

Dr. **Wolfe**. I do have a statement that I've prepared.

Mr. **Morrison**. Excellent, we appreciate your many years of support for this subcommittee. I recognize as I look at the panel and your names that you are all experienced veterans, so we'll appreciate your comments.

Mrs. **Lloyd**. Let's proceed with Dr. Till.

STATEMENT OF DR. CHARLES E. TILL, ASSOCIATE LABORATORY DIRECTOR, ARGONNE NATIONAL LABORATORY

Dr. **Till**. Thank you, indeed. I appreciate the opportunity of again getting to bring the committee up-to-date on the progress that we're making on the IFR. This committee was here at the beginning, and you've steadfastly supported the IFR development. I am extremely grateful for that.

As you know well, we are developing the complete reactor system, reactor, fuel cycle, waste process, all of it. Development emphasis shifts from year to year. In the beginning it was safety. The landmark experiments on EBR-II gave us confidence in the success of the IFR ideas in that area. Then it was to fuel type, to prove that. That's what the whole concept depends upon. Then the new reprocessing scheme.

All of those developments have been successful and we are moving to what any development program that has been successful, what you expect from it. We are in the scale-up stage, and we're in the stage of seeing whether, in fact, some of the developments can be applied somewhat more broadly. To be specific, in EBR-II, we now have complete fuel loadings of the IFR fuel. That will give us fuel data—statistically significant amounts of data on the fuel, and will give us the feed stocks for the new process.

The fuel cycle facility, which the committee visited a year or so ago—progress continues on that—construction progress continues. We have all of the necessary environmental permits to proceed to completion. We will begin the final phase of the fuel cycle demonstration in October of this year. That phase will continue for four years. If things go well, then at that point the technology, I would consider to be a demonstrated fact.

The additional facet of the work is to see if the IFR processes can be adapted to the LWR spent fuel. The key point there is that the process must be cheap and economic and not add to the LWR costs. Pyro processes are simple; we've had a lot of experience with them. We think there is a possibility, a good possibility of that. We started the R&D this year. We hope to continue at an increased pace next year.

In summary, the amounts that the department has submitted for the facilities in Idaho are adequate. I was encouraged by Secretary Young's statements on the LMR funding, although I don't have the breakdown. The amounts that we require are $25 million for the IFR, an amount similar to this year, and $4 million for the actinide recycle work. It is my understanding that the department supports those amounts. Madam Chairman, thank you for hearing me out once again.

Mrs. LLOYD. Thank you very much, Dr. Till.

[The prepared statement of Dr. Till follows:]

TESTIMONY

PRESENTED TO THE
SUBCOMMITTE ON ENERGY
OF THE
HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

March 6, 1991

CHARLES E. TILL

Associate Laboratory Director,
Engineering Research

ARGONNE NATIONAL LABORATORY
9700 S. Cass Ave.
Argonne, Illinois 60439

Statement of

Charles E. Till

Associate Laboratory Director
Engineering Research
Argonne National Laboratory

To the
Subcommitte on Energy
of the
House Committe on Science, Space, and Technology
U.S. House of Representatives

March 6, 1991

Madam Chairman, members of the Subcommittee, I am Charles Till, Associate Director of Argonne National Laboratory, in charge of the Argonne Reactor Development Program.

I appreciate the opportunity once again this year to bring the Committee up-to-date on the progress that we are making on the Integral Fast Reactor (IFR). I take a particular pleasure in doing so because it was to this Committee just a few years ago that I first outlined our ideas for this new reactor concept and it was this Committee who first gave me support and who have continued to steadfastly support these developments over the intervening years.

Madam Chairman, as you know well, Integral Fast Reactor development covers the entire reactor system, not only the reactor itself but also its fuel cycle, both reprocessing and fuel fabrication, and waste management as well. It is our hope to develop a reactor system that answers the questions that people have about nuclear power and leaves no problem untouched. As such, emphasis shifts each year as the development proceeds. Initially, we focussed much of our attention on demonstration of the ability of the IFR to survive accidents of the kind that happened to TMI and to Chernobyl with perfect safety. Safety was foremost and the demonstrations at EBR-II were a spectacular demonstration of the success of the IFR ideas in this area. From there the emphasis shifted to demonstration of the new IFR fuel type. It is the fuel type that makes the revolutionary properties of the IFR possible. Then came the development of the radically new processing technology for reconstituting the spent fuel and improving the waste product.

In the past year with the success of the development activities, our efforts have concentrated on scale-up activities in both the reactor itself and in fuel cycle demonstration. In addition, we have begun a program to investigate the practicality of extending the IFR process work to the waste product of present Light Water Reactors. Thus we have two activities that represent scale-up to practical commercial scale of the developments of the past few years, and a new development that broadens the possible applicability of the development to current problems that face the nuclear power industry. This progression is exactly what one would hope for and expect from a successful development program.

To be specific, our experimental power reactor, EBR-II at Argonne-West in Idaho, has now been completely fueled with IFR fuel alloys, and is generating statistically significant quantities of fuel performance data. At the same time the large amounts of IFR fuel provide the necessary feed stocks for the fuel cycle demonstration coming up.

The Fuel Cycle Facility, the building and equipment that will be used to demonstrate the IFR fuel cycle, which this Committee visited a year or so ago, continues to make progress although construction progress these days is not easy. During the past year all environmental processes have been successfully completed allowing the Fuel Cycle Facility Project to proceed to completion. All the fuel cycle equipment is under fabrication and three of the six major equipment systems have been fabricated and assembled at Argonne-East and delivered to Idaho for remote qualification tests. We will enter the final "IFR Fuel Cycle Demonstration" phase starting in October of this year when cold start-up testing of depleted uranium will be initiated in just six months time. This phase, which completely demonstrates the reprocessing, refabrication, and waste management technique, as well as demonstrating the satisfactory performance of the fuel from these processes, can be completed in just four years time. At this point the technology will be a demonstrated fact.

In addition, however, one of the important aspects of the IFR electrorefining process can probably be further exploited. All minor actinides that build up in spent fuel -- the so-called manmade elements -- accompany plutonium in the fuel product. In other words, actinide recycling, so-called, comes about naturally in the IFR. There is no additional price for it. It is an inherent trait. This has two effects: It adds to the fuel value because in the fast neutron spectrum of the IFR all these manmade actinide elements are just more fuel. When they fission they produce power the same as uranium and plutonium. But also, when they fission, they are removed as a potential problem in the waste disposal. It is the actinide elements that cause the long-term carcinogenic toxicity of nuclear waste. In IFR waste then, the waste product will be substantionally free of actinides and IFR waste should not pose long-term toxic risk for much more than a couple hundred years as opposed to tens of thousands of years as is the case at the present time. The key point is that this comes free in the IFR.

An interesting question, of course, is whether these processes could be extended to economically process LWR spent fuel. This is more problematical and more controversial. However, there has been extensive experience at Argonne in applying these types of pyrochemical processes, like the IFR process, to the oxide fuel that present reactors use. If the processes are to be useful, it is clear that the most important feature that separates them from anything that can be done at present is that they must be simple and economic and not add to LWR costs. In effect, the fuel value recovered from LWR spent fuel must cover the costs of such processing. For this to be true, the processes used must be cheap and simple. Pyrochemical processes have this potential. We have therefore initiated small-scale work on such processes at Argonne this year. It is the Department's intent to support such work until the potential is proven or disproven. The payoff, in more easily handlable nuclear waste, while not easily quantifiable, could be important in the extreme.

Madam Chairman, the Department's budget includes $82.3M for facilities for Argonne-West to cover our experimental breeder facilities, such as EBR-II, the fuel cycle facility, the fuel manufacturing facility, and the supporting activities required for our Idaho site. This amount is adequate. IFR development work requires $25M this fiscal year, an amount similar to expenditures in the present year. The investigation of actinide recycle through simplified processing of Light Water Reactor fuel requires $4M. It is our understanding that the Department is in agreement with all these amounts.

Madam Chairman, we at Argonne thank you and the Subcommittee for your support of the IFR over the years. We wish to recommend that the Committee support the DOE budgets for the IFR, its facilities, and related work in the amounts I have outlined.

Thank you very much.

Mrs. LLOYD. Another member of the family of this committee is Mr. Linden Blue of GA. We welcome you back today, Linden.

STATEMENT OF LINDEN S. BLUE, VICE CHAIRMAN OF THE BOARD, GENERAL ATOMICS

Mr. BLUE. Thank you, Madam Chairman. I've been enjoying the hearings this morning. They've been very interesting and provocative. I've been particularly happy to see the members of the committee dwell in on this question of economics. I wish Mr. Barton were still here. He's interested in small reactors. Have we got a deal for him.

Mrs. LLOYD. Do you think you might sell Mr. Barton one today?

Mr. BLUE. We can give him 175 megawatts that's economical and, I think, that's what he's after.

Clearly, he reflects some of the skepticism about the industry and what it has produced in the past, particularly in terms of cost. When he talks about twenty cents a kilowatt, we understand that. By contrast, I think we're all aiming at that under five cents number. Particularly in this past year, we are extremely pleased with what we have been able to do in refining the design of the reactor. Our estimates now are that because of the design refinements that we have made in this past year, we have reduced our costs about 20 percent net. Capital costs of the reactors will result in close to a 20 percent reduction in costs of electricity per kilowatt hour. I think you would agree that's extremely significant.

Mrs. LLOYD. We're proud of the work that has been done. We're very excited that the Department of Energy is moving forward with the National Energy Strategy. This would not be possible, if it were not for the hard work that has been done by the companies, the corporations that are represented here today and for the past decade and a half. So, this is the result of your hard work.

Mr. BLUE. We appreciate that. Let's also remember in the particular case of the helium reactor, who got it started in its present configuration. Madam Chairman, it would not exist if it weren't for this committee. We think you deserve an enormous amount of credit for this.

Mrs. LLOYD. Thank you.

Mr. BLUE. I would also—I don't know how you had the foresight to recognize how important it was that we get away from our dependence on foreign oil. Certainly, Saddam Hussein has given us a new lesson in that. Beyond that, his lessons are that modern technology can overcome obstacles. Indeed, modern technology can save lives, as we have seen the efficiency of our technologies overcoming the problems in the Persian Gulf.

In this broadened capability of nuclear for solving the energy problems, we think the MHTGR has its brightest future. When we look at the capability, not only for electricity, but for process heat and transportation, we can see that nuclear really can significantly reduce the amount of dependence on foreign oil. It's this technology that is almost uniquely capable of doing this.

In terms of the economics, as I said, we're 20 percent more efficient in terms of our designs than we were when we got started, particularly as a result of our efforts this past year. I would also remind you that we start with a 20 percent greater thermal efficiency than other reactors. As Dr. Zucker will tell you, when we get to the direct drive reactors, they will be in the near order of 50 percent more thermally efficient. So, we're headed in the right direction on that. The economics are coming from the inherent safety of the system—the inherent simplicity, the advantages of factory economics, you've heard this all before.

What is needed in this next year is at least $25 million to carry on the program satisfactorily. I can assure you that we'll make very good use of that. We have to design a low enriched core. We have to have our work with the NRC proceeding. While this $25 million will ultimately come to a figure of $1 billion before the first installation is completed, I would remind you that that billion dollars is roughly only about the equivalent of one week's oil imports. I think, in that context, it's very worthwhile.

I would also remind the committee that it's in the context of a $200 billion a year energy market that we must look at these requirements. This happens to be a technology that is American grown, that can use American technology all the way through and will mean tens of thousands more American jobs. Again, in that context, I think that the $25 million that is necessary this year is fully justified, and a heck of a deal for the taxpayers. Thank you.

[The prepared statement of Mr. Blue follows:]

STATEMENT FOR THE RECORD
FY-92 DOE AUTHORIZATION
MODULAR HIGH TEMPERATURE GAS-COOLED REACTOR PROGRAM

SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT
COMMITTEE ON SPACE, SCIENCE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

LINDEN S. BLUE
VICE CHAIRMAN
GENERAL ATOMICS

MARCH 6, 1991

Introduction and Summary

Madame Chairman and Committee Members:

I am Linden S. Blue, Vice Chairman of the Board of General Atomics. I am pleased to have the opportunity to appear before this subcommittee to testify in support of the Department of Energy's Modular High Temperature Gas-Cooled Reactor (MHTGR) Program. My testimony today is given on behalf of the industrial participants in this program, i.e. Bechtel, Combustion Engineering, Inc., Stone and Webster Engineering Company and General Atomics. Our companies share in ongoing development of this exciting technology.

I will outline our perspective of the MHTGR and review recent programmatic progress. I will discuss:

1. Why the MHTGR should be an important part of our future energy supply
2. Accomplishments of the commercial MHTGR program during 1990 including design improvements and cost reduction
3. A promising avenue to commercialize the MHTGR with optimum benefits of the New Production Reactor (NPR) project.

Reflecting on current events, not since the Arab oil embargo has energy been the focus of so much attention. The crisis in the Persian Gulf is making enormous demands on America's resources, and our role in this conflict is inextricably linked to oil - to energy. We have been engaged in a major war, and our involvement was among others motivated by a need to preserve access to imported energy for ourselves and our allies. My colleagues and I believe the price of America's foreign energy dependence has become excessive. Future policies need to pave a path towards greater energy independence and render us less susceptible to foreign supply disruptions.

The Administration's recently released National Energy Strategy recognizes safe nuclear power as an important energy component in the nation's future. Unlike fossil fuels, nuclear energy does not contribute CO_2 and other gaseous emissions which are harmful to the environment. The members of this subcommittee have long recognized the need for nuclear power in the overall energy equation and the role of the MHTGR as an essential element in our future energy picture. Bechtel, Combustion Engineering, General Atomics and Stone and Webster stand ready to work with the government to usher in the second nuclear era and thus lessen our reliance on other energy sources.

The MHTGR should be an integral part of our National Energy Strategy. This power source offers too many benefits not to receive a prominent place in America's energy future. It is rewarding to observe, therefore, that the MHTGR is gaining acceptance both for commercial and defense missions. The dual application of this technology offers great opportunities for mutual benefits. Thus, given the substantial design commonality between the commercial MHTGR and the MHTGR-NPR, and assuming the NPR FY-92 budget recommendation is implemented, we recommend that $25 million be authorized for the commercial MHTGR program in FY-92. This level of funding will provide for adequate activities and optimum transfer of technology from the NPR and maintain the momentum toward an initial commercial project.

Characteristics of the MHTGR

Public acceptance obstacles encountered by commercial nuclear power must be overcome to provide for secure energy growth in the coming years. If the nation is to preserve the nuclear option, the new generation of advanced reactors must exhibit substantially enhanced safety characteristics which provide very large safety margins.

In the MHTGR with its passive design and inherent safety features we have a system which is specifically designed to provide such margins. This high efficiency reactor embraces a safety design approach which safeguards the public without reliance on engineered safety systems and human interactions. It achieves its fundamental safety by retaining the radionuclides within fuel particles whose refractory coating provide a high integrity primary boundary under all circumstances considered in the licensing process. Therefore, instead of controlling fission products within reactor systems and structures, individual fuel particles act as primary containments (i.e. retention at the source rather than at multiple external barrier).

Furthermore, the MHTGR is not only insensitive to operator error, but even for the most severe postulated events and without operator action, the radiation dose levels at the site boundary do not exceed Environmental Protection Guidelines for which public sheltering is required. These are the types of technical attributes which we find so attractive, and which we believe will be important to gain public confidence and regulatory acceptance.

The DOE's commercial MHTGR program needs to ensure that we maintain and develop this advanced nuclear power plant option to support U.S. electrical energy needs. Many utilities have expressed their desire to maintain the MHTGR as a future energy alternative to benefit their customers. Consumers Power Company has communicated this view in testimony to this subcommittee, and broad utility interest is further evidenced by continuing utility support through Gas-Cooled Reactor Associates. It is also worth noting that the modular design, with its potential for deployment in small power increments, makes the MHTGR not only an attractive alternative for the domestic utility market but also for export to the developing countries.

The high temperature of the MHTGR allows traditional electricity generation using steam conditions comparable with those from today's modern fossil-fired power stations without the attendant pollution problems. Resulting plant efficiencies are around 40%. The MHTGR can also produce electricity in a direct cycle gas-turbine mode with efficiencies around 50%. Beyond that, the MHTGR has the potential for a broad spectrum of uses in the process heat market. It is the only nuclear heat source that can provide the high process temperatures needed for coal gasification, steel making and hydrogen generation.

In summary, the MHTGR is ideally suited to provide a versatile nuclear heat source with unique safety characteristics and broad application capabilities for U.S. and world markets.

Commercial Program Accomplishments

Development of the MHTGR for steam cycle electricity generating purposes continued into the third of a five year preliminary and final design contract with the DOE. The primary contractors include Bechtel, Combustion Engineering, General Atomics and Stone and Webster. Oak Ridge National Laboratory provides technical support while Gas-Cooled Reactor Associates represents utility interests.

The design activities during 1990 generally focused on establishing plant design requirements and design details for systems and components. Technology development and testing were directed mainly at fuel and fission product performance. DOE milestones and deliverables were completed within budget.

One major task undertaken was a Cost Reduction Study. This Study was triggered by the findings of a private-sector feasibility assessment which concluded that the design satisfied all desired safety requirements, and had the potential to further improve plant economics. In-depth scrutiny of the design by technical specialists and government and industry representatives resulted in recommendations for technical improvements and an increase in module power rating. These changes improve the economic competitiveness of the commercial MHTGR while retaining (and in some cases even enhancing) inherent safety margins. A final decision by the Department on adopting the proposed design changes is expected later this year. With their implementation, MHTGR costs are expected to be competitive with comparable sized modern coal and nuclear plants.

In the framework of programmatic highlights, I would like to mention an agreement that recently was signed between General Atomics and the DOE. That agreement provides for GA to relinquish its proprietary HTGR technology, and release relevant proprietary information to the U.S. government with unlimited rights. Recognizing GA's extensive private investments in HTGR technology over the years (about $700 million) and the resulting proprietary rights and patents, this accommodation was made in the interest of advancing DOE's HTGR programs and to facilitate commercialization of the MHTGR.

Commercializing the MHTGR

The MHTGR feasibility assessment completed last year was directed towards institutional and economic issues and defined a viable structure under which the private sector and government could cooperate in sharing the risk and cost of a lead plant. It was the catalyst for the Cost Reduction Study. However, with the NPR now proceeding in the lead role, a new commercialization strategy is being developed.

This emerging strategy calls for maximizing benefits from the leading NPR project to the commercial program through commonality between the two designs. Transfer of know-how is effectively accomplished by adapting design information on a continuing basis as well as utilizing experienced staff as they become available from the NPR program. Furthermore, the strategy requires that the NPR conduct necessary performance testing to support licensing and certification of the commercial design as the fastest path to a commercial plant.

In order to implement this optimum strategy it is essential that major activities on the commercial program continue in parallel with the NPR. It requires early interactions with the NRC to agree on a licensing plan and the resolution of licensing issues. It also requires continuing development of low enriched uranium (LEU) fuel and design activities uniquely related to the LEU core. And, last but not least, detailed component and system designs, as they evolve on the NPR program, need to be adapted to a commercial design where NPR unique requirements do not necessarily result in a commercially competitive approach, or incorporate specific utility requirements for a commercial plant.

Thus, strict coordination between the commercial and NPR MHTGR programs is being implemented to avoid technological duplication and to facilitate certification of the commercial design while saving several hundred million dollars otherwise required for a commercial plant. However, beyond consideration of design and technology commonality, we also visualize the formation of an industrial team, not just to provide a defense reactor, but also to carry forward subsequent supply of commercial plants. This will have the obvious advantage of pooling available MHTGR expertise and clear the way for a successful commercial initiative with minimal support from the government. The recent formation of TRISO Company, a joint fuel supply venture between General Atomics and Babcock and Wilcox, represents an additional step to create the needed infrastructure.

We are promoting such programmatic coordination and are forging the necessary business relationships to consolidate user and industry support of the commercial plant. Thus, the MHTGR will offer not only superior technical features but also the industrial infrastructure necessary to make it a major energy option during the first decade of the 21st century.

Budget Recommendation

Assuming the NPR is funded as proposed, we recommend that $25 million be authorized for the commercial MHTGR. This level of funding is necessary to assure optimum technology transfer as the NPR assumes the lead design and technology development role, and to allow early commercial deployment of the MHTGR.

Commercial MHTGR specific work and interactions with the NRC need to keep pace with the NPR to effect proper consideration of commercial requirements and to maximize benefits from the NPR.

The requested $25 million in FY-92 will help to save a significantly larger amount in future years, which would be required for development of the commercial MHTGR if synergism between the two programs is not fostered.

Madame Chairman, I want to thank you for the opportunity to appear before this subcommittee today.

Mrs. **Lloyd**. Thank you very much, Linden.

It's always a pleasure for me to welcome Dr. Alex Zucker, one of my constituents from the Oak Ridge National Laboratory. He is not only a national leader, he is, I think, one of the foremost scientists in our country. He is also my friend. Thank you for being with us.

STATEMENT OF DR. ALEXANDER ZUCKER, ASSOCIATE DIRECTOR FOR NUCLEAR TECHNOLOGIES, OAK RIDGE NATIONAL LABORATORY

Dr. **Zucker**. Thank you very much, Madam Chairman. It's always a pleasure to appear before this committee, partly because it's so sympathetic to us.

Mrs. **Lloyd**. We're usually pretty good to you.

[Laughter.]

Dr. **Zucker**. We are now in a very fortunate confluence of circumstances in the reactor area because if, as we expect, the NPR MHTGR gets selected next December, it will pave the way for the civilian gas cooled reactor program.

To take advantage of this NPR program, the civilian program must proceed apace. It cannot just be dragged along by the NPR, if we want to maintain any kind of a schedule. The civilian reactor is different. Our hope is that it can be licensed by the end of this century and that we will have a commercial reactor operating by 2010.

At a national laboratory, we always look ahead. We look at new things that are possible and we see that the MHTGR opens up a whole new technology in the gas turbine MHTGR. As you know, the current model has a steam generator, and then creates electricity by running a regular steam plant. The gas turbine generator would use the helium gas that is heated by the core directly to run a turbine. This would eliminate the steam generator and make a simpler reactor. It would make a safer reactor because there is no water involved. The efficiency would go up to 50 percent. This would make it a smaller reactor. It would be a cheaper reactor. It could also be air cooled, which means that it could be located in areas where there is no water for cooling.

That's important in many areas of the world. It consists of small modules, which are factory built, and our preliminary estimates indicate that the power from this reactor is 25 to 30 percent cheaper than from Mr. Blue's reactor, which is already very cheap. I don't want to out-cheap each other, but it is clear that a gas turbine reactor would be more efficient and could be a cost saving item. It is American technology. It's the place where we lead the world. It would make a very good export item, because it's small, it's proliferation proof, and it cannot melt down. So, it can be used in developing countries with a much greater degree of safety and much lower technology than for some other reactors. But, we have to hurry. Other countries will understand this idea as well, and we don't want to get left behind.

Now, let me turn to the budget. Everybody here has said the budget is just fine, and I would like to show that the emperor has no clothes. If the ALMR program is to continue at its level, and if the gas cooled reactor is to continue at what we consider to be required funding, the budget is short by about $10 million. It will require $59.5 million, instead of $49.5 million, to carry both these technologies to a close at the desired time when we want them on line. That, for the gas cooled reactor would be 2010, and for the gas turbine gas cooled reactor, probably 2020.

So, we are looking at, I think, a hopeful and interesting nuclear future, but we have to pay the bill. Thank you very much, Madam Chairman.

[The prepared statement of Dr. Zucker follows:]

Testimony of

ALEXANDER ZUCKER

Associate Director for Nuclear Technologies
OAK RIDGE NATIONAL LABORATORY

ON THE FY-1992 DOE BUDGET SUBMISSION FOR ADVANCED NUCLEAR REACTOR PROGRAMS AND FACILITIES

before the
SUBCOMMITTEE ON ENERGY
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

March 6, 1991

OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee 37831
Managed by
Martin Marietta Energy Systems, Inc.
for the
U.S. Department of Energy
under Contract No. DE-AC05-84OR21400

TESTIMONY OF
ALEXANDER ZUCKER
ASSOCIATE DIRECTOR FOR NUCLEAR TECHNOLOGIES
OAK RIDGE NATIONAL LABORATORY

BEFORE THE
SUBCOMMITTEE ON ENERGY
COMMITTEE ON SCIENCE, SPACE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

March 6, 1991

My name is Alexander Zucker. I am Associate Director for Nuclear Technologies at the Oak Ridge National Laboratory. I am here today to comment on the Department of Energy (DOE) advanced reactors program. ORNL has been involved in technology development for commercial nuclear power plants for more than 35 years, and I have great conviction that nuclear energy has much to offer the world community today and in the future. We endorse DOE's advanced reactor design selections, but feel the budget posture presented in the DOE FY 1992 submission is not optimized for timely deployment of these reactors.

This Committee, above all others, is aware of the portents of our global energy future. World population is growing from the current 5 billion to an estimated 8 billion in fifty years. Burning fossil fuels leads to prohibitive environmental penalties in the form of air pollution and an inevitable increase in greenhouse gases. Conservation is clean and safe, but has little to offer the developing countries where most of the population growth will occur. Solar and renewable energy sources should be developed to the maximum, but the former suffers from technological barriers that have yet to be overcome, and the latter competes for arable land which will be needed to feed the growing population. The world needs a safe, clean and stable energy supply. The United States can again be a leader in the development of such an energy supply.

A critically important part of the energy supply for the future are the advanced reactors currently under development by DOE - the Modular High-Temperature Gas-

Cooled Reactor (MHTGR) and the Advanced Liquid Metal Reactor (ALMR). These reactors offer the potential for safe, clean, inexpensive energy, both for the U.S. and for export markets.

The MHTGR concept, under development since 1985, is based on technology which the U.S. has pursued for 30 years. The MHTGR has a number of favorable design features, including unparalleled passive safety; a fuel cycle which has not yet been closed, offering unique proliferation resistance; flexibility for matching load growth; and factory fabricability for efficient quality control and favorable economics. The MHTGR was selected by DOE as one of the two New Production Reactors (NPR) concepts. A highly focused NPR-MHTGR technology development program now supports development of the NPR-MHTGR design. DOE now has a unique opportunity to leverage a defense expenditure (the NPR-MHTGR) to benefit commercial power. But in order to take advantage of this opportunity, the DOE commercial MHTGR program must be sufficiently funded to develop the technology and design features that are different from the NPR version. Without adequate support for the DOE commercial program, the NPR-MHTGR technology development and design work will be completed, but the opportunity will be lost to benefit the commercial sector. A continued prudent investment of about $25 million per year on the commercial MHTGR, coupled with the ongoing NPR-MHTGR design and technology program, will make possible a commercial MHTGR Final Safety Analysis Report (FSAR) by the year 2000 and commercial operation by about 2010.

The commercial MHTGR should be deployed. It is the only reactor concept under development which has potential for vastly improved economics, while retaining its unique safety advantages. The MHTGR core cannot melt even under the worst accident scenarios, because of its passive safety features and fuel design. Its economic potential is equally impressive. Steam cycle MHTGRs have projected costs which are in the same range as Light Water Reactors (LWRs) and fossil plants. MHTGR designs beyond the steam cycle offer simplicity and improved thermal efficiency leading to most favorable economics, siting flexibility, and export potential.

The MHTGR-GT (gas turbine) is a promising concept for the near future. With this concept, specially designed turbines are directly driven by gas heated by the reactor core. We believe that the simplified design (elimination of the steam generator) coupled with higher thermal efficiency (approaching 50% compared with 33% for LWRs) can produce electricity at bus bar costs 25% below LWR or fossil plant costs. Higher thermal efficiency also provides siting advantages. The MHTGR-GT can be air cooled and deployed at sites without access to cooling water. The MHTGR-GT will operate at somewhat higher temperatures than the steam cycle plant (850 deg C coolant outlet, vs 700 deg C). While most of the technology for the MHTGR-GT is either in place or currently under development for the steam cycle MHTGR, some additional work to develop fuels and materials compatible with the higher temperatures is required. The MHTGR-GT could be licensed and operating within 25 years in a scenario in which the NPR-MHTGR leads first to a steam cycle MHTGR and then to a gas turbine modification of the same reactor. Some additional design and technology development support will be required under this scenario.

DOE's other advanced reactor concept, the ALMR, is now focused on an actinide recycle mission. As you know, the government's inability to resolve the nuclear waste and spent fuel dilemma is a major impediment to increasing production of nuclear energy. The ALMR, with its integrated fuel cycle, has the potential to vastly reduce the volume and hazard duration of nuclear waste. The potential of this concept should be evaluated quickly. If present technical assumptions are validated, and the institutional and economic aspects prove tractable, it can be deployed commercially by the second decade of the 21st century.

DOE's ALMR program also supports several important generic technologies. Most notable are (1) Advanced Controls (ACTO) and (2) Robotics. The General Electric development plan for the PRISM ALMR, supported by this committee, includes an advanced controls program which has become a world leader. We are convinced that the technology advances provided by these two programs will be needed in the future by designers of Light Water Reactors, Advanced Light Water Reactors, Gas-Cooled Reactors, as well as the ALMR, as they seek to improve the safety and reliability of their plants.

But, there is a problem. The DOE FY-1992 advanced reactors budget is insufficient to carry forward both the MHTGR and the ALMR. The lead time required to develop and deploy advanced reactor technology is such that we should not wait until the energy resource problem is acute. And the problem will become acute as increased energy demand due to growth in population and per capita energy use bump up against environmental constraints. To have these needed technologies in place by 2005-2010, the commitment to advanced reactor development must be increased. We recommend that the FY 1991 DOE advanced reactor budget be increased by $10 million over the current administration request, for a total of $59.5 million. This will allow the commercial MHTGR program to be funded at $25 million, and the ALMR design and fuel-cycle programs to be funded at FY-1991 levels.

In making this recommendation, I am aware of a question that is frequently raised within this subcommittee. The question is "...we have been funding the HTGR for 20 years, when are we going to see the benefits of this investment...?" The answer to this question is the NPR-MHTGR. The concept was available because of the wisdom of this committee, which funded an R&D program that resulted in a credible MHTGR design, which could be adapted to tritium production with relatively minor changes. The NPR-MHTGR thus benefited from commercial reactor development. There is a very good chance that the NPR-MHTGR will be selected as the production reactor of choice next December, and that its design, construction and operation in turn will rapidly lead to a commercial power producing version.

We are convinced that the results of DOE's advanced reactors programs will be sorely needed in the decades ahead. The technology will be needed to meet domestic needs, and can also provide a huge export potential for U.S. industry. The markets will be there. If we don't prepare to exploit these markets, we will lose out to foreign competitors. An investment now will pay large dividends in the future.

In summary, our view of the status of the DOE advanced reactor program is that it is not sufficiently funded to develop technology on the schedule that will be needed. Our recommendation on priorities is to set two long-range goals: (1) commercial operation of an MHTGR within 20 years, and (2) validation within 5 years of the technical assumptions which underlie the actinide recycle mission for the ALMR and the integrated fuel cycle. To keep these goals on track, a minimum of $10 million additional funding in the DOE/NE advanced reactors budget is required.

Mrs. **Lloyd**. Thank you very much.

Last week, at our full committee hearing, we heard from one of our witnesses that we should not move ahead. I meant to ask this the previous panel. Unfortunately, I had a call from the Persian Gulf, and I couldn't ask them to call back. Dave Freeman, one of our witnesses who also called the CRBR a technological turkey, made the statement that we should disband our efforts at one step licensing and that we should promote and refine our reactor technology and that would take care of the problem. Would you comment on the level, the degree of public acceptance that you believe our new generation of reactors will have when they are ready to come on line. Any of you that want to comment on that.

Mr. **Blue**. I would take the comment of Fred Buckman, who is President of Consumers Power. In testimony before the Senate, a few days ago that I read, he essentially said that you have to have a very dramatic difference in the technology in order to achieve public acceptance and achieve public confidence. That is key. He used the term "radical" difference. I don't think of our technology as radical, because it is so simple, in fact, it is the simplest technology around. In terms of its ability to provide safety, it is radical. We call it inherently safe. Some people don't like to use the term. We certainly got an idea from the Soviets what inherently unsafe is. I think that when you start with the basis of how this reactor is made, it gives the inherent safety that ultimately that will give the public confidence.

Mrs. **Lloyd**. Alex.

Dr. **Zucker**. It's a question compared to what. I believe the American public understands that no energy is totally clean, that nothing we do is always safe. But, in the next ten years, it will become clear what the situation with the Greenhouse Effect is. The question of air pollution and air pollution control will affect coal plants. If, indeed, carbon dioxide and methane are serious Greenhouse gases that will change the temperature of the globe, people will very quickly understand that they have to make a choice.

They will also understand, I believe, that if the safety record of the reactor installations in this country continues good, as I think it will because of the institutions that have been set up after Three Mile Island, I believe the American people will come around and choose what is a clean and safe technology. As Mr. Blue says, the gas cooled reactor is safe. You can turn the cooling off, you can let the helium disappear, and it won't melt down, it will just sit there.

Mrs. **Lloyd**. Mr. Wolfe, Dr. Wolfe, pardon me.

Dr. **Wolfe**. Yes. I'd like to respond. I think what we've seen in this country over the past seventeen years since the Arab oil boycott of 1973, a surplus of capacity in this country. In this period, in fact, we've had such a surplus—I think, Shelby Brewer mentioned that we've actually had such a surplus that we've cancelled 100 nuclear plants and 80 coal plants in that period and still have had a surplus of capacity. In that period, one could be against coal, one could be against nuclear power, one could be against new dams, one could be against new gas pipelines, and even geothermal plants near fumeroles and potholes.

If you go through the literature, you will find organizations who I've quoted, in a sense, who have been against all of them. It didn't matter. Under those circumstances, you could sit back and say well I don't—all technologies have problems. We could all sit back and say we don't need them. We're now coming to an era where we do need new capacity and we've got to make choices between those alternatives. I believe that when the American public has to make a choice between those alternatives, in particular with the Greenhouse Effect looming on the horizon, and they have to choose a technology or dim the lights, they are going to choose, I think, nuclear power. I think we're coming into a completely different era.

I might just add to what Mr. Linden Blue said, that he has developed a plant with very attractive safety features. I want to make it clear that I believe the light water reactor plants that you heard about have similar features. For example, our advanced boiling water reactor is designed so that even if one assumes a core melt, the off-site dose is such that there would be no effects on the population. They are well below 25 R off site, even if one assumes that the core melts and goes through the vessel.

The same thing goes for the advanced liquid metal reactor. It has safety features also that are extremely good and satisfying. I think all of us have tried to recognize that problem and to develop technologies which, indeed, can be acceptable to the American people.

Mrs. LLOYD. Let's turn to economics, Dr. Wolfe. Elaborate on the potential economic merit of the small modular design. This is a prism to the larger advanced reactor design. Economics has played a large role in our hearing today.

Dr. WOLFE. We've looked—on the ALMR, we looked at the economics and it comes out as it's developed, competitive with the light water reactors and competitive with fossil plants, because the light water reactors, to Mr. Barton's point, are competitive with the fossil fuels. In the case of the ALMR that we're designing—that this Nation is designing—the module is just one part of the plant. That's the reactor part itself, which is really only about 25 percent of the whole plant.

The rest of the plant, the turbine, the power conversion, is in large sizes, so that the cost even of the small module has a relatively—or the larger cost of the small module relative to the lower scale has a very small affect on the overall cost from the whole power plant. When we do the analysis, it comes out very, very favorable, compared to the light water reactors and the fossil fuels, as I said.

Mrs. LLOYD. Dr. Zucker, from your viewpoint, how much progress has really been made over the past two years in R&D as well as licensing effort for the advanced reactors, both the gas and the liquid metal? What milestones have we accomplished?

Dr. ZUCKER. In the last two years, or——?

Mrs. LLOYD. Yes, sir.

Dr. ZUCKER. Well, I think it's sort of commensurate with the funding, really. I know more about the gas cooled reactor than the liquid metal reactor. The fuels being certified where we now have a good deal of experimental data on the temperature effect on the fuel. That's very important. Fuel runs at about 1,200 degrees centigrade. At 1,600 degrees, which is where it would go if the cooling were cut off, the fuel essentially would remain intact forever, or for many thousands of hours, that we've tested it. It doesn't start to degrade until about 1,800 or 2,000 degrees. Those are very important kinds of tests that assure us that the fuel itself serves as the first containment. That means that you don't need a second containment—you don't need these big shrouds around the reactor, and you don't need an evacuation plan. So, those are very crucial determinations that have been made in the last few years.

In the liquid metal reactor, the thing I'm most familiar with is the work on advanced instrumentation. This country is going to need new nuclear instrumentation. The instruments on our reactors that exist are 1960s technologies. The kinds of work that was funded through the ALMR program to develop advanced controlled systems for reactors is applicable not just to the complicated control for the PRISM reactor, where you have three reactors and one steam generator system, but it's applicable to light water reactors, advanced light water reactors and, in general, brings the instrumentation for reactors to the 21st century. I think the accomplishments are numerous. Thank you.

Mrs. LLOYD. Dr. Till, would you like to comment on the IFR progress for the past two years?

Dr. TILL. Yes, thank you. I think I would just like to say a sentence or two on your previous question, in that the degree of acceptance of the public is anybody's guess. The job that we're trying to do, I'm sure all of us, but certainly on the IFR, is to try to get the features of the technology such that they are more acceptable in the sense that the identifiable problems that the public has with their technology, that we're aiming our development at precisely those things. To the degree we're successful, it's certainly, I think, going to be easier to make our arguments.

As to the progress, the progress, I think has been wonderful. You know, our technology is different than the other people on the panel. We're doing development work. By that, I mean, new materials and new processes, very new processes. We stand a good chance, at any point, of not failing, of not succeeding. In fact, the technology for both the fuel and the basic process has now been proven. That's just in the last couple of years. As I said earlier, what we're now involved in is the scale-up. We stand a chance of not succeeding there, again. That's the stage we're in.

Mrs. LLOYD. Thank you. Mr. Blue, I understand the present budget climate—I know if you had an unlimited supply of money, you might have a different story, but under the present budget climate, when would you anticipate a high temperature, heating and cooling reactor to be ready for the market?

Mr. BLUE. We believe that the most coherent schedule would follow the NPR by about two years, which means right about the year 2000. That's real time. It also means that we would need to have the $25 million that I spoke of this year to operate to that kind of a schedule, given that we would expect to have the commercial version ready to follow on in that two-year period.

Mrs. LLOYD. That's very impressive. Mr. Morrison.

Mr. MORRISON. Let me just limit, because of time pressures to one question only. We have lots of enthusiasm for high temperature gas on the panel. I would like to ask, though, Dr. Wolfe, since he is sitting in with this group, perhaps to outline for us the international interest that continues in liquid metal as one of the options on advanced reactors.

Dr. **Wolfe**. Of course, internationally, because of the foresight of nations, in my view, looking towards the future and the fact that we need an essentially limitless supply of fuel, the breeder is receiving support worldwide.

In Japan, they are building the Monju plant; they built the Joyo plant. In Japanese fashion, I'm a great admirer of their technological progress over there and visit them several times a year. As I said, we're building a light water reactor there. They have a program where they plan to commercialize and have the breeder ready in the next century, in the 2020, 2030—actually, their date is 2038. I'm not sure if it's September or October, but they have that planned.

Over in Europe, of course, we have the European programs with the Phoenix and Super Phoenix. I might just say that I think the program we have in the United States is a complement to that and I think, in a sense, a superior program, in that I think the advantage of the module here is that we can build it, test it, refine it, and move it a lot easier than the large plants which the Japanese and the Europeans are looking for. Plants there now, as in Phoenix and Super Phoenix, find a difficulty. Because of the large size, it causes them considerable pain to correct. In any new technology, as Dr. Till indicated, you are apt to find some difficulties.

So, I think there is a worldwide recognition that the breeder is necessary and worldwide motion towards it. I think if we can be successful in this country, we will be leaders in the technology. I think we're going on the right path.

Mr. **Morrison**. Thank you. Thank you, Madam Chairman.

Mrs. **Lloyd**. Thank you, Mr. Morrison, Mr. Stallings.

Mr. **Stallings**. Thank you, Madam Chairman. Gentlemen, it's good to have you here. Dr. Till, we always enjoy your visits here. Let me pose a couple of questions to you. As I reviewed your testimony, and then the budget, you heard Mr. Young talk about the $41 million going towards the liquid and metal. Does that fit within what Argonne needs to adequately fund what you're doing?

Dr. **Till**. Thank you, Congressman Stallings. I don't, of course, have any more information than Secretary Young offered. What I do know is that DOE, from the Assistant Secretary downward, has indicated very strong support for our concept. They are very well aware of the amounts we need. We have been given verbal assurances that they will do their level best to get those amounts to us. I think the amounts that we require which are, as I said, the $25 million for the IFR work, and the $4 million actinide recycle work, and would obviously fit within the $41 million. I don't have the actual breakdown myself.

Mr. **Stallings**. You'd mentioned $25 million in your testimony. Is that about the same sum that you had last year, essentially, a sustaining level?

Dr. **Till**. It's almost exactly the same sum, Congressman, yes.

Mr. **Stallings**. The IFR deals with waste entirely differently from other reactors. The waste contains many fewer long-lived, troublesome elements. This is to be demonstrated in Idaho in Argonne's upgraded fuel cycle facility. This program obviously needs to go forward. Is the funding in the budget primarily for this?

Dr. TILL. The funding for that—and that is the key element this year and in the following years, really, for the IFR demonstration. The funding for that is totally contained within that $25 million request, Congressman, yes.

Mr. STALLINGS. As you are well aware, the waste issue has become the central point in the struggle in Idaho. Part of it's political, part of it's perception. In your opinion, does the IFR really resolve the long term waste problems in this nation, and to what degree?

Dr. TILL. Well, within the IFR technology itself, there is no question at all that the waste form of the IFR will be easier to deal with than the present waste. That's really about as far as you can go. At this point, the processes that you would need to extend it beyond that to the present light water reactor fuel or if you like to, in concept to MHTGR fuel, the processes that you need for that have not been developed.

We're working on the oxide, the light water reactor process, at a very low level today. As I said, the key feature of it has got to be that it's cheap. That's the only problem with the present processes. There is a chance to do that with the adaptations of the IFR process, but it would be a very brave man that tried to prognosticate that it's going to be successful and it's going to have, you know, the following consequences that can be measured in terms of this many billions of dollars, or what have you.

So, in summary, within the IFR itself, the waste product will be, of no question, a lot easier to deal with. Whether you can extend it, still has to be shown.

Mr. STALLINGS. I think you would also have to factor in the tremendous amount of money we are putting into the Yucca Flats controversy, as well as the overall amount we are spending on waste clean up. I think you're right, that's it's got to be economical, but I think there are other factors that are going to be taken into consideration. Even with the handling of the waste costing a little more through the IFR, it would still be considerably cheaper than to put things in storage for thousands and thousands of years, I would think.

Dr. TILL. The key thing in this is that the development succeed. That still has to be shown.

Mr. STALLINGS. Thank you. I appreciate that.

Mrs. LLOYD. Thank you, Mr. Stallings. Thank you gentlemen for your testimony. We appreciate your being with us today. We will be submitting questions in writing for you to respond to for the record. Thank you very much.

Mr. Morrison is going to introduce our next panelists.

Mr. MORRISON. Thank you, Madam Chairman.

I'm pleased to introduce two of the members of the team that, as I mentioned earlier in my opening statement, took on the challenge that Congress provided for them. That was to see if a major facility that was part of the Clinch River Breeder Reactor Program, the Fast Flux Test Facility, could, in fact, get enough international support that we could relieve some of the budget pressures that we have found here as our nuclear energy R&D budget has been reduced for most of the last decade. I'm pleased to have Jeff Breckel, who is the representative to the Governor and leader of this effort on behalf of the State of Washington, and Roger Nichols, with Westinghouse Hanford, as key members of this team.

I'll mention that they are just freshly back, as a matter of days, and I've had a chance to meet briefly with them, but I look forward to their report. They are backed up by Art Stevens, also with Westinghouse Electric Corporation; Phil Jones, who used to be with Senator Evans' staff here on the Hill and is our resident expert on matters related to the Japanese; and Kevin Billings, who is with Westinghouse Hanford, as a congressional liaison. Gentlemen, we're pleased to have you here. Jeff, I guess you're listed first and, again, thanks to the Governor and to your leadership in helping in this effort.

STATEMENT OF JEFF BRECKEL, SPECIAL ASSISTANT TO THE GOVERNOR, STATE OF WASHINGTON

Mr. **Breckel**. Thank you. I think we have perhaps a unique situation here in this morning's hearing. We're not talking about a new reactor development program, but I think we're talking about a facility that has been and can continue to be an important contributor to new reactor development activities, both here in the United States, as well as abroad, through new opportunities for international collaboration.

The State of Washington has a special interest in FFTF. We view the Northwest as a center for energy research and development activities, and we see the FFTS as an integral and important element in that role. We would very much like to see that facility continue. We believe that it has the capability of making an important contribution, both to the national and international research communities, in terms of energy research and isotope production.

The facility is the largest and most modern test reactor in the world. It began operations in 1982, and has much remaining life left to it. In the intervening years since 1982, its mission has been diversified, reoriented. It has handled a wide range of activities in terms of the development and testing of reactor materials and fuels, as well as branching out into isotope production and supporting the international fusion research community.

The Governor was very disturbed last January when the Secretary advised him of his intention to close the facility. The Secretary advised the Governor that he felt the DOE's missions alone were no longer sufficient to support the facility. Given growing fiscal pressures, he had no alternative other than to make a very regrettable decision to close FFTF.

In response to that and in recognition of the contribution that FFTF had made in the areas of isotope production and international collaboration in the past, the Governor set about to explore opportunities that might be available to expand those international and commercial applications to a level that would support continued, long term operation of the facility.

Last Spring, as part of that effort, the Governor sent teams to Japan and to Europe to meet with governmental representatives and nuclear energy officials in those areas. Another team met with radio-pharmaceutical companies here in the United States to talk about the isotope market. The results of those trips were very promising. We found, collectively, that a claim for FFTF in its unique and flexible capabilities was widespread.

There was great interest in seeing the continued operation of the facility. Through our own projections, based on the preliminary information we gathered, we felt that these non-federal users could conceivably contribute as much as 50 percent of the facilities budget, within a three to five year period of time.

However, I have to stress at that point that although DOE had provided technical support to our market assessment, they were not an active participant. One of the questions that we were continually asked in terms of suggesting that there might be an opportunity for international collaboration was whether DOE was really interested in such an alternative.

As a result of our findings and Congress' action to continue FFTF funding through fiscal year 1991 and endorsement of our marketing project, the Secretary joined with the Governor to assist in more fully exploring the market opportunities. I must stress that we very much appreciate the Secretary's support. Without it, we would not be able to have substantive discussions with the prospective clients out there. DOE is, after all, the owner and operator of the facility, and our role, as an interested party makes it essential that they be represented.

The Governor and the Secretary agreed to ask Westinghouse again to provide technical support for our marketing effort. They have agreed to do so, have jumped in with both feet, and have been very active and very aggressive in providing us with the support we need to make this a success.

Congressman Morrison has introduced legislation with the support of the Washington delegation, which has also provided important impetus and momentum to our effort. That legislation would facilitate DOE's efforts to commercialize FFTF, but most importantly, it recognizes the need to make long term operating arrangements with prospective clients. That's one of the most crucial elements that we came across in our discussions with potential users during the Spring.

Our expanded campaign has focused on the Japanese, as Mr. Nichols will talk about in his presentation. We had some very productive meetings with Japanese interests here just over a week ago. We found that they have done considerable consideration of FFTF over the last year. They are more than ever interested in seeing the facility stay open. I think more importantly, and more indicative of their growing interest, they are asking us what shape an agreement with the United States would take with regard to an international partnership.

While our focus has been principally on Japan as perhaps being the most interested party, we have not forsaken the other prospects we looked at last Spring. The Westinghouse Hanford Company team has been in Europe. They have talked to German and French officials. The Germans have discussed the possibility of providing fuel for FFTF. There has been discussion of an international FFTF users group being formed.

In summary, we cannot predict success at this time, because our discussions are detailed, and in depth discussions with the potential are just beginning. We're very, very pleased and encouraged by the results we have received here in just the last few weeks. Given time and, I think, given the continued active support of DOE, the Secretary, and Congress, we believe there is an excellent opportunity to make FFTF truly an international, multi-mission research facility. One that will not only meet the needs of the domestic energy research programs, but also those of the international community. Thank you.

[The prepared statement of Mr. Breckel follows:]

THE FAST FLUX TEST FACILITY

Efforts to Establish
an
International Research Center

Testimony
of
The State of Washington

before
The Energy Subcommittee
of
The House Committee on Science, Space, and Technology

March 6, 1991

STATE OF WASHINGTON
OFFICE OF THE GOVERNOR

OLYMPIA
98504-0413

BOOTH GARDNER
GOVERNOR

TESTIMONY OF JEFF BRECKEL
March 6, 1991

Good morning. Mr. Chairman and Committee Members, my name is Jeff Breckel. I am appearing before you this morning on behalf of Governor Booth Gardner. The Governor appreciates this opportunity to share his thoughts regarding the Fast Flux Test Facility located on the U.S. Department of Energy's Hanford Reservation in Washington State.

The FFTF - A Proven Resource for the Future

The State of Washington has a special interest in the FFTF. It is the keystone to Hanford's continuing role as a center for energy research and development.

As you are probably aware, the Hanford Reservation is in transition. Defense programs, the mainstay of Hanford operations for over four decades, are being phased out. Efforts are now underway to clean up and dispose of the massive quantities of wastes generated by these programs. In addition to its historical role in defense programs, Hanford has also been an important site for the nation's energy research and development efforts. While environmental programs will likely be the site's primary mission for the next several decades, Hanford is also in the position to continue to make important contributions to national as well as international energy programs. And, FFTF is poised to play the central role in these efforts.

FFTF is the largest, most modern nuclear test reactor in the world. It began operations in 1982 as an experimental reactor in the U.S. advanced breeder reactor program. In the intervening years, DOE has reoriented and diversified its mission to encompass the development and testing of reactor materials, fuels and components as well as international fusion research and isotope production. FFTF has attracted international clients, including Japan's PNC and JAERI. It has amassed an exceptional operating record and it is staffed by a highly capable and talented staff of technicians, engineers, and scientists. In short, FFTF has in its nine years of operation demonstrated its value as an important state, national, and international asset.

An Assessment of Potential New Users and Missions

Given FFTF's record, Governor Gardner received the announcement last year that DOE planned to close the facility with great concern. Secretary Watkins advised the Governor that he regretted the decision but that DOE missions alone could no longer support continued operation of FFTF.

In response to the announcement, the Governor set out to determine if international and commercial uses of FFTF could be increased to a level which would support long-term operations. Technical teams were sent to Europe and Japan to meet with government agencies and businesses involved in nuclear programs. A third team met with radio-pharmaceutical firms here in the U.S.

The results were promising. The market assessment indicated that non-federal programs could fund up to one half of FFTF's annual operating costs within 5 years. The teams found widespread acclaim and enthusiasm for FFTF and its unique testing capabilities. Nowhere was this interest stronger than in Japan, which has embarked on an aggressive liquid metal reactor program.

A Focused Marketing Effort

As a direct result of these findings, Congress funded FFTF through fiscal year 1991 in hope that new users and funding sources could be found to support continued long-term operations. Late last year, Secreatry Watkins joined the Governor to assist in more fully exploring the potential for increasing international and commericial utilization. The Secretary's active support and participation is critical to the marketing effort. Without the involvement of the facility's owner, substantive discussions with prospective users would be impossible.

The Governor and the Secretary also asked Westinghouse, DOE operating contractor for FFTF, to provide technical support. Further impetus to the effort was provided when the Washington State Congressional delegation, led by Congressman Morrison, introduced legislation which would facilitate DOE in entering into long-term agreements with prospective FFTF users.

The expanded campaign to seek out new users is focusing initially on Japan. Japan demonstrated the greatest interest in FFTF during our discussions last spring. A team led by myself, representing Governor Gardner, and Tom Hendrickson, Principal Deputy Assistant Secretary for Nuclear Energy, travelled to Japan on February 20 to initiate discussions with Japanese government agencies and nuclear-related businesses. Roger Nichols of Westinghouse coordinated the meetings and led a team of Westinghouse support staff.

While it is yet too early to predict success, the mission to Japan was productive and encouraging. The Japanese responded favorably to our proposal of establishing a Japan/U.S. operating partnership for FFTF. They recognize the unique technical capabilities of FFTF and openly acknowledge its potential value to their liquid metal reactor program and to international fusion research. They are clearly interested in gaining access to FFTF and are curious about what form an agreement with DOE might take. They also understand that unless we can show serious interest in FFTF by non-federal users, the facility could be closed permanently.

While our principal focus has been on Japan, discussions with European parties have also been initiated. A Westinghouse Hanford Company technical team recently met with German and French officials. They found considerable interest in using FFTF to support the European Fast Reactor program. The German's offered fuel for FFTF. And, the concept of establishing an international FFTF utilization working group was explored.

In summary, our discussions with prospective users of FFTF are just beginning. The early results are encouraging, but not conclusive. Given adequate time and the support of DOE and Congress, we believe that the prospects are promising for making FFTF a multi-mission, international research facility.

Thank you.

Mr. MORRISON. Roger?

STATEMENT OF ROGER C. NICHOLS, DEPUTY GENERAL MANAGER, GOVERNMENT OPERATIONS, WESTINGHOUSE HANFORD CO.

Mr. NICHOLS. Thank you. My name is Roger Nichols. I am the Deputy General Manager of the Westinghouse Government Operations Business Unit, which has responsibility within Westinghouse for most of the Government Owned/Contractor Operator contracts we have with DOE, including the one at Hanford. I've been in Hanford about two and a half years, and just in January moved to this new position, so I am somewhat familiar with the FFTF issue.

Mr. Breckel gave a very good summary of the background of the marketing effort. I would like to focus on our recent trip to Japan. As a result of the earlier missions that he discussed last May, the team concluded that the largest potential for near-term support for continued operation of FFTF rested with the Japanese institutions and entities that have been involved with FFTF in the past, almost since the beginning of operation in the 1980s.

Our approach to the Japanese was basically to offer a new relationship with the FFTF. In the past, they have been basically purchasers of services. In this new relationship, we propose to create a partnership between DOE and Japan in the operation of the FFTF. It would be a partnership in a somewhat limited sense, in that DOE would retain an operating responsibility for the facility in compliance with the laws and regulations, and also retain responsibility for the ultimate disposal of the facility. Japan and Japanese entities would become a partner in the operation of the facility, with a significant contribution to operating costs.

We think this is a tremendous value to the Japanese, because what we're offering has value to them. We're not offering just to become a contributor of cash, but a receiver of technology from the past operations of FFTF, from the past experiments and technologies that DOE has developed, that the Japanese have not had access to in the past. As was noted in prior testimony, the Japanese are focused on a demonstration fast breeder reactor program that will be operational early in the next century.

They are continuing very, very heavy efforts on the development of liquid metal reactor and breeder reactor prototype plants. The Monju plant will start up in about a year and a half from now. It is in essence about the design of the Clinch River Breeder Reactor that the United States was designing some years ago. FFTF will be an excellent compliment to their program. It has been. In fact, they were very disappointed last year when it was announced that the FFTF was going to close, because they had several long-term experiments they were about to put in the reactor, as part of their breeder reactor program.

We met with 20 institutions, organizations, and individuals who have input to the energy R&D and planning process and policy making process in Japan, including the Japanese ministries. The support from DOE was extremely helpful this time; in particular, the very positive letter from the Secretary of Energy that was sent to the Minister of International Trade and Industry and the Minister of the Science and Technology Agency. These two agencies have the primary responsibility for energy research and development and nuclear research and development in Japan.

The priority quasi-governmental agency that has been interfacing with FFTF is PNC, or the Power Reactor and Nuclear Fuel Development Corporation. We had meetings with them as well as other interested institutions, manufacturers, and even some diet members who are interested in this process.

The reception of all was very, very good, but there are some problems to be overcome if we are going to be successful. First, the Japanese are very concerned about the long-term nature of the use of FFTF. It's a very critical element of their long term energy program, the breeder reactor development. Without a clear and firm understanding of the long term use of FFTF, it's going to be difficult. They don't want to risk getting into the middle of a long-range program and face continued uncertainty.

Secondly, there are large numbers of organizations in Japan that could have either a near term or a long term interest in FFTF, and coordination of these interests, in a Japanese sense, is a long and arduous process. It will require time for them to arrive at a consensus to accept the kind of partnership proposal we have talked about. If it were just one institution, the process would be somewhat easier.

Thirdly, and most importantly, I think the Japanese fiscal year budget cycle is essentially six months off of the U.S. budget cycle. They are in the final process of approval of their fiscal year 1991 budgets, which begin April 1st. There is essentially no hope of getting programs or processes in that budget for funding for FFTF through their fiscal year 1991. In fact, because many of the organizations that had planned use of FFTF this year saw the potential closure of FFTF, they sought alternatives for their missions in 1991 and, therefore, really have no plans that could be loaned to FFTF at this time. Significant additions to the budgets could only start in their fiscal year 1992, which is April of next year. Indication of those plans could be available as they submit their final budget proposals to their Minister of Finance, which is the equivalent of the OMB.

The Japanese were very, very pleased with the support shown by DOE. They were, in particular, very pleased by the support by the Congressional Delegation in the State of Washington. They were also very pleased by the legislation submitted to Congress, HR-910, which gave them some feeling of comfort that there was, indeed, a sense of desire to create a long-term process for FFTF.

Our plans, in the near term, are to continue dialogue with the important agencies. We expect responses to the official proposals that have been made, possibly responses to the letters from Secretary Watkins to the ministers because they were official communiques. Hopefully, we will take technical teams back to Japan in April to discuss detailed technical issues with them, and as Mr. Breckel said, develop a framework for the kind of agreement that could be posed.

We believe there is great hope and prospects for such an agreement, but we need to overcome some of the hurdles that I described. We really appreciate the support of this committee in these efforts and look forward to your continued support in the future. I have submitted a detailed technical statement which includes the Governor's Report the team produced last Spring, and would be happy to answer questions. Thank you very much for this opportunity.

[The prepared statement of Mr. Nichols follows:]

TESTIMONY OF

ROGER C. NICHOLS

BEFORE THE

SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT

COMMITTEE ON SCIENCE, SPACE AND TECHNOLOGY

OF THE

UNITED STATES HOUSE OF REPRESENTATIVES

MARCH 6, 1991

INTRODUCTION:

My name is Roger C. Nichols and I am the Deputy General Manager of the Westinghouse Government Operations Business Unit which has overall responsibility for several of the Government Owned/Contractor Operated (GOCO) operations of Westinghouse for the Department of Energy (DOE). The Westinghouse Hanford Company (WHC), which operates the Hanford reservation, is part of that business.

BACKGROUND:

The Fast Flux Test Facility (FFTF), located at Hanford, Washington, is a state-of-the-art 400 MWt, sodium-cooled test reactor. The FFTF is the only U.S. Department of Energy reactor that has undergone the independent Nuclear Regulatory Commission scrutiny normally required for commercially operated reactors. The FFTF achieved full power operation in 1980, and began unrestricted operation in 1982. Since that time notable achievements include records for operating efficiency and continuous operation at full power, fuel burnup records four times those achieved in the commercial industry, full scale demonstration of passive safety features, demonstration of isotope production capability, and the successful operation of advanced materials tests in support of fusion and space power development.

On January 29, 1990, the Secretary of Energy announced that due to budgetary and mission considerations that the Department of Energy was recommending, subject to congressional approval, the closure of the FFTF in April of 1990. When the decision was announced, there were more than twenty full scale experiments underway supporting U.S. and international programs. Upon review of the recommendation, Congress asked that closure be delayed until October of 1990 and that a careful look be taken at impacts and alternatives. In view of interest and concern for the FFTF, both domestically and internationally, Governor Booth Gardner of the State of Washington launched an initiative to evaluate funding alternatives outside the DOE. The Governor's initiative was endorsed by the Secretary of Energy.

In April 1990, the Governor and Westinghouse Electric Corporation provided seed funding to support his initiative to evaluate market potential for non-federal users of the FFTF. A group of technical and business experts from Westinghouse, Battelle's Pacific Northwest Laboratory, the State of Washington and the local community was assembled as a marketing team. After review of potential marketing areas, the team was divided into subteams which focused on potential European, Asian and domestic users.

During this time, DOE began administrative procedures related to shutting down the FFTF, including meeting with the Japanese and others that had experiments in the facility. The Japanese reaction to DOE's explanation was negative reflecting both the lack of prior notification of termination and the general confusion over DOE's logic. All parties were assured that their interests would not be affected adversely by the decision to shut down the FFTF.

Despite these assurances, the Japanese customers were very distressed by the DOE plans to remove an integral part of their Fast Breeder Reactor (FBR) test program, a fuel irradiation test. Because of the DOE announcement, the Japanese immediately initiated plans to place the irradiation testing in the PHENIX Fast Reactor test facility in France. In addition, the Power Reactor and Nuclear Fuel Development Corporation (PNC) the major Japanese user of the FFTF to date used this opportunity to obtain budget approval from the Japanese Diet for the upgrading of their JOYO, Experimental Fast Reactor (Liquid Sodium) which currently has an output capacity of 100 MWt. The upgrade program was announced as a 70 billion Yen ($550 Million) program over a five year period. Also, investigations were initiated to find an alternative for continuing the international fusion material irradiation testing program [illegible] in FFTF. The EBR-II test reactor of DOE in Idaho was considered but rejected by the experimenters as inadequate.

THE FFTF MISSION DEVELOPMENT MARKETING INITIATIVE

The Governor's marketing team described earlier began an intensive effort to assess potential new sources of funding for the FFTF, so that viable options could be offered to the DOE.

In May and June of 1990, Market team members met with 22 potential non-DOE clients throughout the world in an effort to assess the interest in the FFTF and to analyze, within the context of international energy needs, the existing potential for and place of the FFTF in the United States energy plan. The organizations and contacts engaged in the dialogue on which the team's conclusions are based are listed in Appendix A which is the team's report to the Governor.

PRELIMINARY CONCLUSIONS OF THE MARKETING TEAM

The conclusions of the Marketing Team are contained in detail in the report to Governor Gardner which is attached as Appendix A. The FFTF is seen by the international energy community as a very important and valuable asset and that it is an important part of the nation's and the world's energy future and that every reasonable effort should be expended to keep it in operation.

There are four areas in which the FFTF can provide a valuable service: Irradiation Services, Testing, and Experiments; Operations and Balance-of-Plant Testing; Nuclear Waste Destruction Experiments; and Medical Isotope Production. These areas can be considered core missions.

The team believed it was clear that a new role could be defined for the FFTF in the future and continue to make valuable contributions to energy research and development in the U.S., as well as internationally. However, the transition from a solely DOE facility for advanced reactor research and development to an international facility with multiple users will take time and patience.

Two other factors were also clear from the many discussions held by the marketing team. First was that additional support and funding for continued operation of FFTF from non-DOE sources would require better assurance of long term operation. Secondly, most of the organizations which held discussions with the marketing team members were interested in exploring the potential of expanded use of and participation in the operation of FFTF, but were unwilling to pursue the matter without a clear indication of the position of DOE. As there were no representatives of DOE with the teams, no further progress could be made.

Following the completion of the marketing efforts in the summer of 1990, the report to the Governor was presented to DOE and discussions on how to proceed were held. Additionally, Congress appropriated funds to continue the operation of FFTF through FY 1991 and encouraged DOE to seek outside sources of funding. Based on the efforts conducted in 1990, the conclusion was reached that the most likely source of a significant long term source of new funding and uses for the FFTF would be Japanese organizations. Discussions between Governor Gardner's office and DOE produced and agreement that would include DOE representation in the next marketing efforts. It was also decided that although the potential for support from European interests was low in the near term, that a series of return visits should be made to Europe to update the situation.

A strong market exists in Japan from a variety of sources for use of the FFTF. This certainly stems from a long history of cooperation and use of the reactor combined with Japan's commitment to a long term breeder reactor development program and its impeccable reputation for adhering to those commitments. The types of uses for the reactor offer a rich blend of technology that takes full advantage of all of the reactor's capabilities; materials testing, core-wide testing, component testing, balance of plant, operations and maintenance experience and isotope production. Japan has stated the need for such work to be performed and they have demonstrated willingness to participate given the existing experimental work in progress.

CURRENT STATUS - JAPAN

As a result of agreements between Governor Gardner and DOE, it was decided that Westinghouse Electric Corporation, and its subsidiary, Westinghouse Hanford Company, would be enlisted to support the marketing efforts. Following a number of internal strategy meetings held in Richland, Washington, a series of preliminary meetings were arranged with liaison officers of Japanese firms and relevant officials of the Japanese Embassy in Washington, D.C. Meetings were also held with the State Department. We reviewed the basis of our marketing initiative and explained that the purpose of our meetings in Washington was to inform them of our plans to seek a major partnership in Japan for the continued long term operation of the FFTF. In addition, we were soliciting their advice and counsel on how best to proceed with this effort.

In our meetings with the U.S. Department of State we were advised that a letter from the Secretary of Energy would provide a strong introduction to our proposed meetings and would add a high degree of credibility to the FFTF Marketing Initiative. This advice was later reinforced through our meetings at the Japanese Embassy.

Secretary Watkins sent letters to Ministers of two key agencies in Japan involved in nuclear energy and energy development. They are the Ministry of International Trade and Industry and the Science and Technology Agency. Copies of these letters are included as Appendix B. In his letters, dated February 7, 1991, Secretary Watkins expressed his support for the initiative undertaken by Governor Booth Gardner "to find new and expanded uses for the Fast Flux Test Facility." Further, he expressed his belief that the facility "has much to offer to the international nuclear community." Similar letters were sent to the Ministries by Governor Booth Gardner of the State of Washington and the Washington State congressional delegation.

As a result of these letters, meetings were arranged in Japan beginning on February 18, 1991, with key public and private sector interests, to further explore the feasibility of a partnership with Japan for the operation of the FFTF as an international research and development facility.

The marketing team consisted of personnel from Westinghouse, Governor Gardner's staff, and the Department of Energy. The list of organizations and agencies included in the marketing meetings is attached as Appendix C.

MEETING AGENDAS

The meeting introductions were made by Mr. Tom A. Hendrickson, Principal Deputy Assistant Secretary for Nuclear Energy, US-DOE. Mr. Hendrickson explained the DOE position and expressed the DOE's desire to establish a framework for the continued long-term operation of the FFTF. He further defined the DOE's responsibilities for the facility, including its safe operation in compliance with DOE requirements.

Mr. Jeffrey P. Breckel, Special Assistant to Governor Gardner, explained the State of Washington's interest in the FFTF. He noted the value of the FFTF as an international research center in the U.S. Pacific Northwest and the long and productive trade relationship between the State of Washington and Japan.

Mr. Roger C. Nichols, Deputy General Manager of the Westinghouse Electric Corporation's Government Operations Business Unit, outlined the corporations commitment to nuclear energy development and the valued history of the Japanese relationships that Westinghouse has maintained for many decades.

Mr. Denny J. Newland, Deputy Manager of Operations for the Westinghouse Hanford Company provided a description, capabilities and accomplishments presentation on the FFTF.

Mr. Nichols then explained the basis of the FFTF Marketing Initiative to Japan. This was described as follows:

O Develop a new relationship; a partnership with Japan to:

  - Broaden and strengthen existing relations.
  - Improve utilization of the FFTF for mutual benefit.
  - Provide a foundation for expanded international cooperation.

O Potential Benefits to Japan:

  a. Facility risks are very low

    - The FFTF is built and a success
    - Operations will still be U.S. responsibility
    - Final disposition of the facility will be U.S. responsibility.

  b. Improved access to existing experience and technology.

    - Lessons learned in start-up and prior operations.
    - Sharing of testing experience.

c. Expanded use of access in the future

- Operational experiences as plant ages
- Valuable resource for MONJU and DFBR programs.
- Possible Steam Generator testing capability.
- Special operations and safety testing.
- Potential for nuclear waste transmutation studies.
- Potential source for medical isotopes.

Mr. Nichols then presented the Marketing Team's plan for a partnership. This plan would include the creation of a Memorandum of Understanding (MOU) between the governments of Japan and the U.S. This MOU would establish the concept of a partnership for the long term operation of the FFTF and an approach for equitable sharing of costs and benefits, as well as for the plant operation. We told the meeting attendees that in order to implement this agreement, an existing agreement could be used, or a new agreement could be negotiated. The team didn't present this concept for an MOU as a fixed proposal, but rather as a means to begin discussion.

Our suggested timing for reaching an agreement on an MOU was April 1991, recognizing the coming congressional budget deadlines. We did, of course, indicate some flexibility on this date.

In summary, we proposed a U.S./Japan partnership to share the FFTF utilization and operating costs for the mutual benefit of both countries. We noted that significant Japanese participation was needed during U.S. FY 1992 in order to demonstrate the desire for mutual cooperation. Following a formal agreement, the parties could then consider additional international participation in the FFTF.

SUMMARY OF MEETINGS IN JAPAN

We believe that the key government agencies are the STA and MITI. STA, in particular, oversees the budgets of PNC and JAERI, which have been carrying out some experiments at the FFTF. Our proposal for a U.S./Japan partnership for the FFTF was generally well received. Most Japanese parties recognize that the FFTF is an excellent operating facility with broad capabilities in FBR research and development, as well as for fusion materials and testing. There is also considerable interest in using the FFTF as a test bed for some nuclear waste burn experiments. But there are also considerable difficulties that must be overcome due to the timing of our request and the amount of funds we need to sustain the continued operation of the FFTF.

The value to Japan of participating in an international research and development program utilizing the FFTF is well recognized and acknowledged. The difficulties cited most frequently were the problems of coordinating the views of several Japanese Government agencies and institutions and the incompatibility of the Japanese Government budget cycle, which begins in April, and the U.S. Government budget cycle, which begins in October. Both STA and MITI officials told us that it would be extremely difficult to provide any funding in JFY 1991, but that they would be willing to give serious consideration to projects and funding for JFY 1992 (starting April 1, 1992).

FUTURE ACTIONS PLANNED

Despite these obstacles, we intend to aggressively pursue our discussions with STA, MITI, PNC, JAERI, JAPC and other interested parties over the next several weeks and months. Meetings have been scheduled in Washington, D.C. for the week of March 4 to further pursue this subject and to provide follow up reports to Japanese Government and utility personnel. In addition, DOE, Westinghouse and State of Washington personnel stationed in Japan will provide follow up support. We expect it to be necessary to travel to Japan frequently over the next few months. We have tentatively set a target date of April for our next trip.

CURRENT STATUS -- EUROPE

Dr. Alan Waltar, Manager, Advanced Reactor Programs, and Dr. Dave Lucoff, Manager of FFTF Operations, both of Westinghouse Hanford Company, visited with several European community members. The intent was to explore potential participation on the part of the European community in the "internationalization" of the FFTF. In addition to the direct benefit of European community participation, internationalization is recognized as a key factor to Japanese participation in the operation of the reactor.

The trip was very successful, the French and Germans were both enthusiastic about utilization of the FFTF in support of their European Fast Reactor (EFR) program. Their primary interest is in passive safety testing, they also expressed interest in transmutation and advanced fuels development. In fact, the Transuranic Institute of Germany has requested cost estimates for some near term developmental testing in the reactor. France and Germany have agreed to participate in an International FFTF Utilization Working Group meeting tentatively scheduled for early this May. We anticipate that the Japanese and the United Kingdom will also participate in that meeting, and we've extended an invitation to the IAEA. The primary emphasis of the meeting will be on passive safety testing with secondary discussions on other potential uses of the facility.

The European community typically does not have the financial resources to invest significant funding in the FFTF. Their participation would be in the form of technical expertise and test hardware. However, the Germans have offered in excess of $50 M worth of fuel for the FFTF. Utilization of this fuel could significantly reduce the operating cost of the FFTF for a period of three to five years.

We are very encouraged by the response we found in Europe and believe that groundwork has been laid for truly internationaling the FFTF. We envision cooperative programs in passive safety testing, transmutation development, and advanced fuels development that would include the European community, Japan, and the United States.

POTENTIAL FUTURE U.S. PROGRAMS

Funding constraints led DOE to decide that they could not justify continued operation of the FFTF. However, if we are successful in finding partners in that operation, there are numerous U.S. programs that we anticipate would make use of the unique capability of the FFTF.

PASSIVE SAFETY TESTING

The nearest term need for the FFTF is passive safety testing in support of the development of the Advanced Liquid Metal Reactor (ALMR). This reactor program places considerable emphasis on the development and demonstration of passive safety features. The FFTF is the only reactor in the United States capable of performing prototypic scale tests of these features. The international community has also expressed significant interest in these tests.

METAL FUEL TESTING

The U.S. ALMR program is based on metal fuel. Several entities, including program review bodies, have recommended that testing of prototype fuel assemblies should be initiated on a priority basis utilizing the FFTF if it continues in operation. Full scale testing is recommended to accurately measure effects impacted by size, the FFTF is the only U.S. reactor with sufficient size for testing of full length fuel pins.

ADVANCED FUEL TESTING

As noted above, metal fuel is the reference fuel for the ALMR program; however, there are problems such as a large void coefficient that still need to be resolved. As a contingency, the U.S. is also studying the potential for nitride fuel. If nitride is determined to warrant more detailed study, the FFTF will be required to provide the necessary fuel performance data base.

TRANSMUTATION TESTING

The transmutation of nuclear waste constituents is currently being examined as a way to reduce the uncertainties associated with he performance of radioactive wastes disposal systems. In approximately five years the DOE will be ready to perform pilot scale demonstration of waste transmutation. It is anticipated that the FFTF will play a key role in the development and demonstration of this technology to allow successful incorporation into advanced liquid metal reactor designs, as well as provide critical technology for accelerator based waste transmutation systems.

SPACE POWER TESTING

Space power development is required to support programs such as the recently announced Space Exploration Initiative (SEI). The development of advanced fuels and materials for space power applications can be significantly enhanced through testing in FFTF. When the DOE determined that full funding of the FFTF could not be maintained, a significant reduction of space power irradiation development tests was required. Continued operation of the reactor will allow resumption of the original plans.

FUSION MOTA

The U.S. is one of the principal users of the Fusion MOTA and had planned to utilize that capability for several more years. Assured long term operation of the facility will allow those plans to proceed.

NAVY ADVANCED REACTOR DEVELOPMENT

The U.S. Navy has expressed a strong interest in a FFTF testing for materials tests in support of advanced reactor concepts. Discussions were discontinued when DOE announced the planned shutdown. The Navy is currently performing uninstrumented tests in EBR-II, assured operation of the FFTF wll allow planning for fully instrumented testing to proceed.

COMMERCIAL APPLICATIONS

There are two capabilities of the FFTF which lend themselves to commercial applications, isotope production and electrical power generation.

Isotope Production

There is a rapidly growing market for radiopharmeceuticals in the medical industry. Industry projections show that market increasing from the current level of $200 Million per annum to over $3 Billion per annum by the year 2000. Currently the capability to produce these isotopes in the United States is limited. As an example, there is no U.S. facility producing molybdenum-99, the most frequently used isotope today. Current U.S. needs are purchased from Canada. A recent design study has shown that the FFTF is capable of producing up to one third of the world's requirement for this isotope.

Additional studies have shown that the FFTF is particularly suited for the production of many other isotopes through the use of a "rabbit" vehicle which is now in the design stage. The spectacular market growth projected is in developmental isotopes which would be produced in this "rabbit".

Power Generation

The energy generated by the FFTF is now dissapated to the atmosphere. This energy could be utilized to generate approximately 120 MW of electricity. In 1986 a cooperative agreement was established between the local public utilities and the DOE to explore feasibility of a utility owned power addition to the FFTF. The result was a design, cost estimate, and schedule which showed that a power addition could be completed in four years which would supply electricity at rates comparable with other sources in the Pacific Northwest and California.

The major stumbling block to the power addition project has been the lack of a long term mission for the FFTF. If long term operation of the FFTF can be assured, there is a high probability that investors will be willing to fund

Appendix A

Report to the Governor
on the
Future Funding Potential
of the
Fast Flux Test Facility

Submitted by the Marketing Team
Ralph DiSibio, Chairman
Jeff Breckel
Ersel Evans
John Nolan
Adrian Roberts
Mike Schwenk

June 6, 1990

Table of Contents

Introduction and Summary 5

The Fast Flux Test Facility 9

FFTF Market Analysis - Europe 17
- The Potential 17
- Market Analysis 18
- Conclusion 18

FFTF Market Analysis - Japan 21
- The Potential 21
- Market Analysis 23
- Conclusion 23

Isotope Production 25
- The Potential 25
- Market Analysis 26
- Conclusion 27

FFTF Power Addition 29
- The Potential 29
- Market Analysis 29
- Conclusion 30

Irradiation Services to the U.S. Department of Energy 31
- The Potential 31
- Market Analysis 31
- Conclusion 34

Financial Analysis 35

Assumptions and Conclusions 43

Appendix 47

Introduction and Summary

Introduction

On January 29, 1990, the Secretary of Energy announced the Department of Energy's (DOE) decision to close the Fast Flux Test Facility (FFTF) located in Richland, Washington. Upon review of the recommendation, Congress asked that closure be delayed until October and that a careful look be taken at impacts and alternatives. In view of interest and concern for the FFTF, both domestically and internationally, Governor Booth Gardner of the State of Washington launched an initiative to evaluate funding alternatives outside the DOE. The Governor's initiative was endorsed by the Secretary of Energy.

In April 1990, the Governor provided seed funding to support his initiative to evaluate market potential for non-federal users of the FFTF. A group of technical and business experts from Westinghouse Electric Corporation, Battelle's Pacific Northwest Division, the State of Washington and the local community was assembled. After review of potential marketing areas, the group divided into teams which focused on potential European, Asian and domestic customers.

Two reasons were cited for the DOE's decision to close the FFTF. First, the Advanced Reactor Program, which has provided nearly all funding to the FFTF in the past, has suffered from diminished support and can no longer afford the FFTF. Second, the Assistant Secretary for Nuclear Energy was unable to identify a new mission for the FFTF within the DOE portfolio. The Marketing Team, therefore, focused on commercial and international missions beyond the conventional bounds of DOE programs.

Background

In the meantime, the DOE's Nuclear Energy organization began administrative procedures related to shut down, by meeting with the Japanese and others who have experiments in the facility. In these meetings, the reason for the decision was explained and plans were set forth to satisfy interested parties that their needs could be met at other facilities, or that the DOEwould assist in a phase-out of their experiments. The parties were assured that their interests would not be adversely affected by shutdown of the FFTF.

It has becaome very clear that there are two important factors influencing the DOE's decision. First, as noted above, cost is a consideration. In a major budget crunch, it is difficult to justify operation of both FFTF and the EBR II reactor. Second, the metal fuel option appears to be a better fit with the Energy Department's fuel cycle strategy. Although it is possible that closing the FFTF is necessary to eliminate any costly competition to the metal fuels initiative, the majority opinion is that -- given the necessary funds -- the nation would be best served by keeping the FFTF operational.

Approach

At the Governor's request, Westinghouse Electric Corporation began to assess potential sources of funding for the FFTF, so that viable options could be offered to the DOE. The intent of Westinghouse and all involved in the study was to serve the Department, the State of Washington, and the nation.

Market team members met with 22 potential non-DOE clients throughout the world in an effort to assess interest in the FFTF and to analyze, within the context of international energy needs, the existing potential for and place of FFTF in the United States' energy plan. The organizations and contacts engaged in the dialogue on which the teams conclusions are based are listed in Appendix A.

Results

The results of these meetings indicated that, the energy plan and budget ramifications notwithstanding, FFTF is an important part of the nation's -- and the world's -- energy future, and that every reasonable effort should be expended to keep it in operation. The following paragraphs summarize the potential for supplemental funding which could become available to FFTF.

There are four areas in which the FFTF can fill some needs of governmental and commercial entities worldwide: Irradiation Services, Testing, and Experiments; Operations and Balance-of-Plant Testing; Nuclear Waste Destruction Experiments; and Medical Isotope Production. These areas can be considered core missions. The most important untapped potential would seem to lie in waste destruction experiments and medical isotope production.

Other possible uses--such as fuels testing for the British Navy, or irradiation testing of components for the Power Reactor and Nuclear Fuel Development Corporation (PNC), or fusion research for the Japan Atomic Energy Research Institute (JAERI) and the International Atomic Energy Agency, and general international collaboration--are interesting but insufficiently defined for accurate assessment at this time. If and when they develop further, they can provide additional missions for the facility.

Power Addition, or production of energy for commercial sales, can also be regarded as a core mission --but one which faces major institutional and funding hurdles on the road to implementation. However, it has potential support in the local community and the region, and is important to one potential contributor in Japan. It should be pursued as a supplementary mission.

Potential clients for FFTF services are national and international, governmental and commercial, and combinations of these. Some of these customers seek data in irradiation, testing, experiments, and operations which can be provided through FFTF. Others are looking to FFTF for waste management and isotope production services. Features of these potential markets are noted below.

***Irradiation Services, Testing, and Experiments*:**
The ability of the FFTF to perform efficient services in this area is unchallenged. The open issue is whether or not the present research customer base can be maintained as part of an overall business base necessary for economic viability of the facility.

The FFTF has already accumulated significant irradiation experience on four types of fuel: oxides, carbides, nitrides and metal. It is an excellent test bed for further tests and evaluations of fuel designs and performance in support of the Department's program of IFR and PRISM development.

A critical consideration in this area is the ongoing dialogue between the Department and the Japanese, which has the objective of convincing the latter that their objectives can be met at EBR-II following closing of the FFTF. The Japanese clearly need the experimental services they have been receiving at the FFTF, and they clearly have the financial resources to support those services. For this reason, they viewed the potential closing of the FFTF with dismay, and expressed their intention to refurbish the JOYO reactor and place additional experiment in the Super Phenix reactor in France to meet future needs. Now, in view of the Department's assurances in regard to EBR-II services and the attempts by this team to solicit support for continued operation of FFTF, the Japanese are understandably confused. However, we believe that a reversal of its closure decision by DOE and strong assurance of access to FFTF in the foreseeable future, combined with an intense marketing effort, could generate $20M to $30M of business per year. A clear signal, indicating a long-term commitment--in other words, overt DOE support--is required for success with this customer.

The European community also has extensive needs for these services -- needs which are currently being met by other facilities. The European facilities, however, are aging. The team was repeatedly told that research reactors in the United Kingdom and Belgium are scheduled to close, and that France is the only potential provider of the services. Even France cannot hope to answer all the needs of the community. Western Europe is thus, although not a near-term client, a consideration in any future plan for the FFTF. The European entities with whom the team spoke expressed stronger interest in close collaboration than in financial support; such collaboration might be expressed through sharing of data or running experiments in one another's reactors without cost.

The emerging eastern bloc was consistently mentioned by western Europeans as a group who would require services of the type available from the FFTF. The specific requirements and potential contribution of this entity are, of course, an unknown quantity. However, they constitute another piece of the puzzle which lends to justification for maintaining the viability of FFTF.

The capabilities and the client base are essentially the same for corewide testing and for irradiation services. FFTF capabilities in irradiation services are unique, because of the size of the facility and the rigors of the tests it underwent to simulate the NRC approval process.

Operations and Balance-of-Plant Testing

FFTF's ability to simulate nearly full-scale operations under conditions of regulatory compliance allow the facility to play a singular role in the international community. The facility can act as a test bed for operations and thus prove invaluable to those facing a licensing, procedure development or general operations issue.

The safe performance of the FFTF is unparalleled in the industry. For this reason, it is viewed as ideal for operator and inspector training by Europeans and Asians, given their increasing interest in disciplined reactor operations. The Institute of Nuclear Power Operations standards and the facility's Operational Assurance Program provide an excellent base for development and testing to be used in other reactors' components and systems.

Nuclear Waste Destruction Experiments

The Secretary is committed to resurrecting the nuclear option. One of the initiatives identified for this purpose is solving present and future waste issues. It is clear to the team that FFTF can play a significant role in achieving this goal. The FFTF has already demonstrated the potential to transmute actinides and other long-lived fission products (technetium and iodine) through laboratory-scale experiments in 1989. Larger-scale prototype tests to fully demonstrate the concept of waste burn can be carried out in the FFTF in the next three to four years, in support of the Secretary's initiative. No other reactor in the United States has sufficient capability to perform these tests.

Whether or not future reactors use metal fuels, successful waste destruction experiments can provide crucial information. FFTF is well placed to perform a spectrum of experiments with broadly applicable results. In addition to dealing with the actinide issue, and thereby addressing the problem of waste generation in future plants, FFTF experiments can have important implications in the cleanup of defense waste, considering the billions of dollars expected to be spent in this arena. Although the team is not prepared to project cost savings, the impact is clearly significant. FFTF is ideally suited, technically and geographically, to play a role in waste destruction.

Medical Isotope Production

Almost all (approximately 95%) of the radioisotopes used for medical purposes in the United States are produced on foreign soil. The medical isotope production industry is growing significantly -- by some estimates, it will expand dramatically in the 1990s. While the market expands, the sources for these raw products shrink. In fact, a monopoly is beginning to form which may soon corner the market. Chemical and pharmaceutical firms are in search of an expanded and stable supply source.

The FFTF has the capacity to supply the needs of a significant portion of the world's requirements of many isotopes and, indeed, will be able to produce most of the isotopes needed, providing additional experiments are successful.

It is important to note that a major investment ($20M) would be required to produce medical isotopes for commercial distribution. Four large domestic radiopharmaceutical companies and Sorin (Italy) have indicated a willingness to buy these products, and would consider being involved in a carefully structured private effort to initiate a commercial enterprise.

Of the four core missions assessed, this one lends itself most to a typical business approach and balance sheet analysis. However, because of its many issues which are outside the expertise of team members, it is reluctant to predict final outcomes at this time. The technical capability of the facility, plus the increasing market appear to be compelling arguments for a continued assessment, exploring the entire market. This assessment is covered within our overall recommendations.

Conclusion

The team's travels and dialogues indicated the FFTF is an international asset which is worth keeping in operation, given its potential to attract supplemental funds from several sources, its ability to contribute to the initiatives begun by the Secretary, and the many unknowns in the international energy picture. It is clear that a new role can be defined for FFTF. However, the transition from government and research facility to, possibly, a commercial production facility will take time and serious consideration. We believe it is imperative that operation of the reactor continue while a newly constituted entity representing the facility's various constituencies -- actual and potential -- devise and implement a plan for mission transition, which identifies measurable objectives for market exploration and development as well as continued contribution to the nation's energy future.

The Fast Flux Test Facility

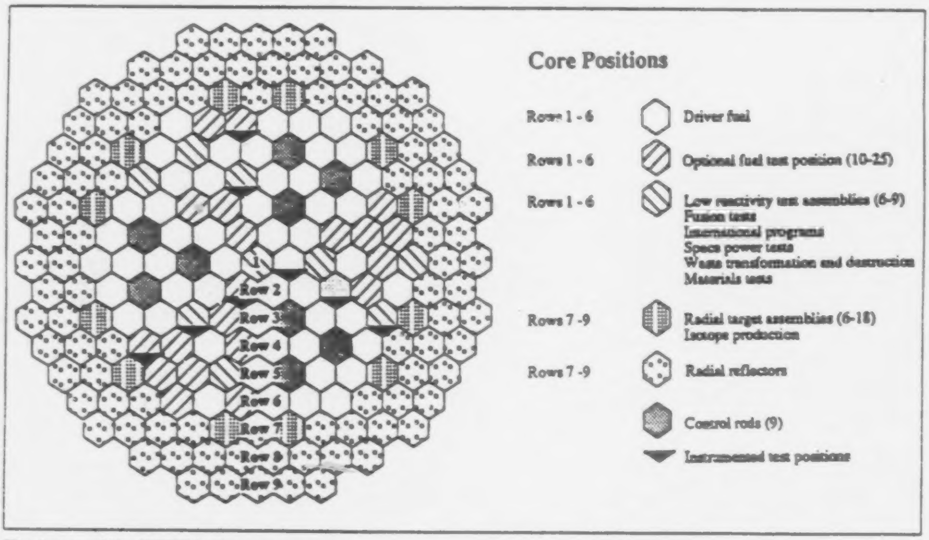
Introduction

The Fast Flux Test Facility (FFTF) is a U.S. government-owned 400-MWt sodium-cooled, fast neutron flux reactor plant that was constructed in the 1970s, began producing neutrons in 1980, and has been operating since 1982 as the most versatile test reactor in the world. It has produced outstanding records in fuel performance, has demonstrated capabilities to produce medical isotopes and destroy or transform radioactive waste, and has operated safely to stringent nuclear standards.

Support in the United States for liquid metal reactors was sharply reduced during the last decade, particularly after Congress stopped the construction of the Clinch River Breeder Reactor in 1983. Current nuclear energy planning does not consider that advanced concept reactors will be needed until after the first quarter of the next century. Thus, the original mission to test nuclear fuels and materials has been reduced to a very low level at the present time. A large number of other missions have been under active consideration for the FFTF during the past several years. Each mission depends on the superior capabilities of the FFTF to perform the required development, testing, and production as described below.

Reactor Characteristics

The FFTF was originally designed for irradiation testing of nuclear fuels and materials for liquid metal fast breeder reactors. The reactor coolant is liquid sodium, which has the appearance of a silvery liquid and has fluid characteristics comparable to water. Sodium permits the nuclear fission reaction to occur without the degradation in energy of the neutrons that occurs with water as the coolant, as is the case in today's commercial nuclear plants. The retention of the high energy of the neutrons produced in the fission process is the basis for the term "fast flux." Because of the heat removal characteristics of the sodium coolant, the FFTF generates a very high density of fast neutrons, resulting in accumulating neutron exposures faster than is feasible in commercial plants. The thermal output of the reactor is about one-eighth that of a commercial nuclear plant such as WNP-2, but all of the FFTF's excess energy is currently being dissipated to the atmosphere.


1
Row 2
Row 3
Row 4
Row 5
Row 6
Row 7
Row 8
Row 9
Core Positions
Rows 1 - 6
Driver fuel
Rows 1 - 6
Optional fuel test position (10-25)
Rows 1 - 6
Low reactivity test assemblies (6-9)
Fusion tests
International programs
Space power tests
Waste transformation and destruction
Materials tests
Rows 7 -9
Radial target assemblies (6-18)
Isotope production
Rows 7 -9
Radial reflectors
Control rods (9)
Instrumented test positions

The heart of the FFTF is the reactor core.

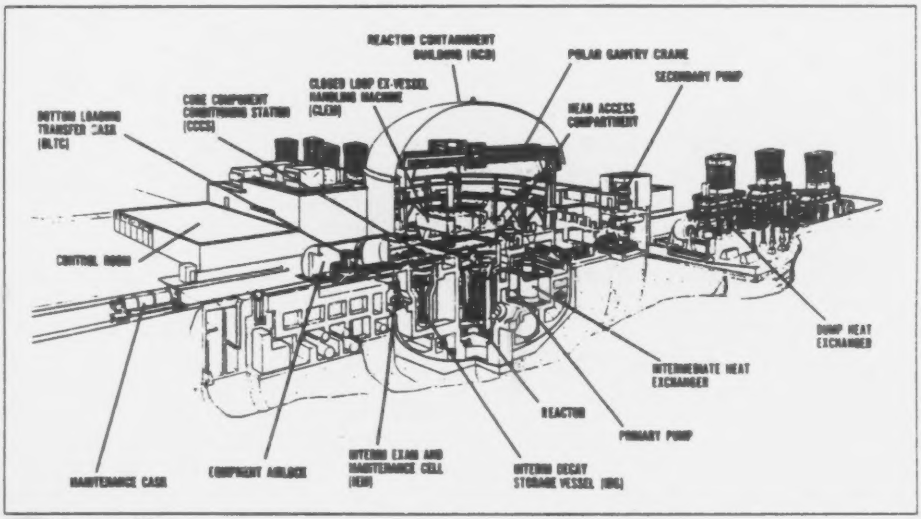
Core components fit into 91 hexagonal positions, each 4.5 inches across. There are 74 fuel positions, eight instrumented test positions, and nine positions for neutron absorbers to control the fission process and the power level. The fuel assemblies have normally consisted of 217 cylindrical pins containing a mixture of uranium oxide with about 25% plutonium oxide. The instrumented test positions have been used to measure temperatures and other parameters of fuels, neutron absorbers, and materials. Control rods in the FFTF use boron carbide to absorb neutrons, thereby controlling the nuclear fission process. Three rods are used for fine control during operation. Six additional rods are poised above the core, providing assured shutdown under all circumstances.

Surrounding the reactor core are 108 hexagonal reflector positions, which reflect neutrons back into the core, thereby making the core more efficient in neutron usage and also preventing radiation damage to long life components external to the radial shields. Most of these positions are occupied by assemblies which can be removed and replaced by test assemblies for isotope production.

Balance of Plant Characteristics

The reactor vessel surrounds the fuel and reflector regions and provides the structure to support other components. The core support structure and the core restraint system keep all the assemblies in correct alignment and provide the supply of sodium required for cooling through each assembly. Instrumentation above the core measures temperatures and flow of the sodium coming out of the core assemblies, providing a unique measurement capability. An in-vessel handling machine transports core assemblies into the core and back out after use. The top of the reactor vessel has ports for entry and removal of core components, and hardware to move the control rods.

The reactor containment building encloses the reactor vessel and the entire primary sodium system. Three pumps circulate the liquid sodium through individual piping systems into the reactor vessel core, and then through three separate heat exchangers. The heat exchangers transfer the heat energy to three secondary, non-radioactive sodium systems very comparable to the primary systems. Other components in the reactor containment building include large cranes, core component handling machines, systems to control instrumented tests, and an Interim Examination and Maintenance Cell (IEM Cell). The IEM Cell provides a unique capability to take in both instrumented and standard core components, remove residual sodium, measure distortion and dimensional changes caused by irradiation, disassemble into individual pins, identify ruptured pins, and package for shipment to other locations. The IEM Cell personnel also reassemble Materials Open Test Assemblies (MOTAs) for further irradiation. The MOTA is discussed further below.


REACTOR CONTAINMENT BUILDING (RCB)
POLAR GANTRY CRANE
SECONDARY PUMP
CLOSED LOOP EX-VESSEL HANDLING MACHINE (CLEM)
HEAD ACCESS COMPARTMENT
CORE COMPONENT CONDITIONING STATION (CCCS)
BOTTOM LOADING TRANSFER CASK (BLTC)
CONTROL ROOM
DUMP HEAT EXCHANGER
INTERMEDIATE HEAT EXCHANGER
REACTOR
PRIMARY PUMP
MAINTENANCE CASK
COMPONENT AIRLOCK
INTERIM EXAM AND MAINTENANCE CELL (IEM)
INTERIM DECAY STORAGE VESSEL (IDS)

FFTF Cutaway View.

External to the reactor containment building are a variety of additional facilities. Three secondary sodium systems incorporate pumps and dump-heat- exchangers where the heat energy produced in the reactor core is dissipated to the air. The Reactor Service Building contains systems for handling and purification of the gases used in the reactor vessel and other facilities. The Fuel Storage Facility provides for storage in sodium of used fuel and other core components prior to final disposition. The Maintenance and Storage Facility has the capability to clean, decontaminate, repair and store plant components. Additionally, the Fuels and Materials Examination Facility, located adjacent to the FFTF, has the future potential capability to produce operating and test components for the FFTF.

Safety continues to be a prime consideration at the FFTF. Three protection levels surrounding the fissionable fuel in the reactor core include the tubing containing the fuel, the reactor vessel, and the containment vessel. Safety in depth has been designed into the FFTF, including the intrinsic safety properties of liquid sodium, which operates far below its boiling point and at very low pressures compared to water systems. The many reactor design features include redundant and diverse shutdown systems. Maintenançe and upgrading of plant systems and the training and experience of its most important resource, the people who operate it, also contribute to plant safety.

FFTF Testing Capabilities

Emphasis has been on testing in the reactor core and reflector regions, primarily because of the original design intent to do so. However, completion of the Power Addition project would permit testing of steam generators in addition to the currently proposed plant systems and components testing.

The reactor's size, neutron flux, and instrumentation are the bases for its superior testing capabilities. The 36 inch fueled zone core height enables testing of full size assemblies for proposed commercial plants and also provides the bulk volume needed for testing materials in the quantities required for design verification. The high neutron flux permits timely completion of testing, faster than in comparable commercial plants. All core positions have instrumentation located immediately above the assembly, which measures both sodium flow and temperature.

The real testing versatility is based on the eight instrumented positions in the core which permit sophisticated control of operating conditions for materials testing and measurement of the environment of fuels, absorbers and fusion blankets. The most frequently used testing capability is in the MOTA. This highly instrumented assembly has up to 54 individual canisters -- 30 located in the reactor core, 18 above the core, and 6 below the core. Most of the in-core canisters are temperature controlled. The remainder of the canisters operate at the temperature of the surrounding sodium. A recent modification of the MOTA design has resulted in direct, on line, real-time measurement of the tritium production and release characteristics of fusion breeder materials.

Experiments can be located in one of the many hexagonal positions in the core or reflector. Each position can be tailored specifically for the experiment, providing prescribed conditions of neutron flux, neutron energy levels, temperature, and coolant flow rate. As an example, many fuel assemblies have been tested using larger than standard fuel pins of oxides, carbides and metal fuel forms. Also, fuel tests have been conducted under a wide variety of startup and operational conditions.

Determining how reactor core components will perform together under normal and abnormal operating conditions is possible in FFTF through partial-core or full-core demonstrations. Partial-core testing of the Core Demonstration Experiment, consisting of ten fuel and six blanket assemblies, has exceeded three years operation. Performance evaluation of this experiment has provided confirmation that designers can use this testing approach for commercial reactor fuel concepts. Full-core demonstrations of actual or customer-representative reactor components also are possible in the FFTF. This feature would offer actual fuel management experience and would create a substantial fuel performance data base through testing in a monitored environment. Tests could readily be performed in support of the United States PRISM reactor under development by the General Electric Company and the Integral Fast Reactor (IFR) concept under development at Argonne National Laboratory.

Full-core safety testing was conducted in 1986 to 50% of FFTF rated power. Loss of sodium flow testing, which could be caused by pump failures or loss of electricity, resulted in an improved set of computer program predictions of reactor conditions during an actual event. Testing in FFTF is representative of conditions in loop-type sodium cooled reactors, whatever the size. Further testing to 100% power could be performed in support of future reactor designs.

Testing Accomplishments

Core component testing for liquid metal reactors has resulted in several world records. Over 50,000 oxide fuel pins have been tested to burnups nearing 200 megawatt-days per kilogram of fissile material, over four times that being obtained in the best light water reactors. Test parameters have included major variations in cladding, pin size, fuel composition, temperature and power level. Two carbide fuel assemblies were irradiated using specialized hardware to reduce the number and cost of the fuel pins. Individual nitride fuel pins have been tested for the Space Reactor Program. Much higher than normal pin surface temperature conditions were accommodated by using specially designed test hardware. Testing of the nitride fuel form is well on the way to verification of performance for early space reactors. Metal fuel assemblies are being irradiated in FFTF and have provided the first real-time characterization of axial metal fuel swelling during early stages of irradiation.

Three control rod designs have been tested in FFTF. Design lifetimes have been extended from 400 equivalent full power days (EFPD) to over 900 EFPD. One instrumented test of boron carbide provided temperatures and gas release data while in the reactor. Several other boron carbide tests explored temperature and lifetime characteristics far beyond the boundaries required for commercialization, exceeding levels attained elsewhere. A very advanced control rod, originally designed for the Clinch River Breeder Reactor, provided valuable information for producing and validating new designs.

Isotope production in the FFTF has been extensively studied and demonstrated. Specifically, we have tested the production of more than 30 medical isotopes. Medical isotopes can be produced with appreciably higher purities and qualities in FFTF than in any other U.S. reactor, because of the ability to modify the neutron energies at a specific location to enhance isotope production. In 1986, the reactor made the highest specific activity gadolinium-153 ever produced in the world. In 1989, the Multi-Isotope Production test irradiated more than 30 target isotopes to verify production physics predictions. Three of the radioisotopes, selenium-75, osmium-191, and rhenium-186, were delivered to university and medical researchers. Domestic and international demand for medical isotopes appears to be rapidly increasing.

Studies and tests on high-level nuclear waste chemical partitioning and reactor recycling (or waste burn) are under way in Japan and Europe. The FFTF is capable of fissioning or transmuting the major detrimental waste isotopes. This was demonstrated in 1989 in the Multi-Isotope Production test where two fission products, technetium-99 and iodine-131, were transmuted into a harmless gas and a stable element.

Special Capabilities of the FFTF

Several special capabilities of the FFTF are exploitable for future development. These include low temperature materials testing for light water reactors and tailoring the neutron characteristics in specific locations for producing isotopes and fissioning or transmuting nuclear waste products.

Early in the design of FFTF, a Closed Loop In-Reactor Assembly (CLIRA) was designed and partially constructed to test fuels under off-normal conditions, including melting. High costs resulted in deferring completion. However, new concepts, using some of the CLIRA hardware, indicate that a low temperature capability can be installed in the FFTF at a reasonable cost. The test vehicle would be somewhat similar to the MOTA, resulting in controlled temperature conditions. Experimenters from Japan, Canada and the United States have requested this testing capability in FFTF in order to provide high fluence results more quickly than is possible in any other test reactor.

The reflector region of the reactor has typically been underused for testing. However, the neutrons present in this region have highly desirable characteristics for producing as many as 40 isotopes needed for biomedical applications. The environment in this region can be tailored, using specific materials combinations and configurations, to produce at least 30 isotopes having better quality characteristics than those produced in any other reactor in the United States. Additionally, the flux characteristics provide broad ranging target capabilities to transmute fission products or to fission higher actinide nuclear waste products. This transmutation or destruction of nuclear waste could save billions of dollars in permanent disposal costs and reduce the required isolation time from more than 10,000 years to just a few hundred years.

FFTF Operational Performance

The FFTF, although operated primarily for the benefit of experimenters, has had a remarkable operational record since power operations began in 1982. The Operational Efficiency Factor (OEF), a measure of actual operations compared to planned operations, has averaged over 98%. In 1987, the OEF was 100%. The plant Capacity Factor has averaged 63%, which is comparable to the average U.S. commercial plant during the same time period.

Most test reactors operate for short periods of time, usually in the 60 to 80 day range, between shut downs for refueling or experimental purposes. The FFTF exceeded 100 days of continuous operation in 1984, again in 1987, and operated for 126 days in 1988. These test reactor operating records clearly demonstrate the reliability and capability of the FFTF for experimental purposes.

List of Accomplishments

November 1982.	First operating cycle lasted 53 days longest ever achieved for a sodium-cooled reactor.
March 1986.	Produced gadolinium-153, a rare isotope used in the early detection of osteoporosis.
July 1986.	Demonstrated passive safety features, including "automatic" nuclear shutdown during which cooling pumps were stopped with no reactor scram.
February 1987.	Demonstrated, through fuel tests and new alloys, the potential for future reactors to operate from five to 10 years without requiring refueling. Fuels achieved more than 150% of their designed burnup.
April 1989.	Set another fuel burnup record of 190,000 megawatt days per metric ton of fuel. By this time, the same fuel assemblies had been in the reactor for seven years.
November 1989.	Completed fourth Integrated Leak Rate Test, demonstrating continued structural integrity of FFTF reactor containment building.
January 1990.	Completed the equivalent of three years of operation on the Core Demonstration Experiment, demonstrating the promise of a truly long-lived fuel design and material.
February 1990.	Celebrated tenth anniversary of reactor criticality.

Comparison of Test Reactors in the World

The FFTF is the newest and most advanced test reactor in the world. Its combination of high flux density, extensive test instrumentation, and size are unmatched by any other test reactor. As shown in Table 1, most test reactors world-wide were constructed in the 1950s and 1960s. Several key test reactors are scheduled for closure, including PFR, PLUTO, and DIDO in the United Kingdom. Many others, like the 29 year old BR-2 in Belgium, are approaching the ends of their safe, useful operating lives. The demise of these reactors places an additional imperative upon the continued availability of FFTF for testing and production programs on a global scale.

Projected Operating Costs

The direct operating cost of the FFTF and its associated facilities, including core component supply, is approximately $78M for FY 1991. An additional $6M is required in construction and capital equipment costs. This annual cost can be extrapolated on a cost escalation basis for the next several years. These costs are based on operation with mixed uranium-plutonium oxide fuel, thereby not requiring the extensive analyses to convert to another fuel form.

Table 1
Major Test Reactors World Wide

Name	Location	Power (Megawatts Thermal)	Type	Age (Yrs.)
FFTF	USA - Wash.	400	Liquid Sodium	8
JOYO	Japan	100	Liquid Sodium	13
PFR	United Kingdom	600	Liquid Sodium	15
PHENIX	France	563	Liquid Sodium	17
KNK-II	Germany	58	Liquid Sodium	19
ATR	USA - Idaho	250	Water	23
EBR-II	USA - Idaho	62	Liquid Sodium	27
BR-2	Belgium	100	Pressurized Water	29
NRU	Canada	135	Heavy Water	33
PLUTO	United Kingdom	25	Heavy Water	33
DIDO	United Kingdom	25	Heavy Water	34
NRX	Canada	42	Heavy Water	43

FFTF Market Analysis - Europe

Introduction

The FFTF team visited representatives of the principal European nuclear energy development communities during the period May 7 through May 16, 1990, to determine potential, for future FFTF funding support. Past interactions with Europe have indicated that their development programs have been scaled down over the previous decade. Most current programs are being conducted as multi-national efforts targeted for possible deployment of advanced reactor technologies beyond the year 2000. Although several European countries previously supported relatively self-contained advanced reactor programs, only France has been able to maintain that stature. Multi-national partnerships have provided a cost-effective means of retaining Europe's nuclear technology infrastructure in the face of delayed large-scale deployment. With this prior analysis of the European market for FFTF services, it was clear that near term funding was unlikely but that collaborative exchanges between FFTF and the ongoing European programs were a possibility. The team also sampled the European market for new customers for medical radioisotopes.

The Potential

The potential European customers for FFTF services are as follows:

European Fast Reactor Program
This is a relatively new collaborative partnership which merges many elements of the United Kingdom, German and French fast reactor programs. The effort focuses on design and construction of a demonstration plant intended as the forerunner of a common design reactor suitable for construction and licensing in the partner countries. The plant could be operational by 2005. Current needs for irradiation tests are being fulfilled by the prototype Fast Reactor in the United Kingdom (scheduled for 1994 shutdown) and Super Phenix in France.

The Commission of the European Community (CEC)
The Research and Development Directorate General of the CEC has two directorates with potential interest in irradiation services: Reactor Safety and Fusion Technology. The Reactor Safety Program is the central nuclear fission effort within the CEC and is not heavily funded. Its initiatives focus on safety of nuclear power plants and on licensing and waste issues. The fusion program is a modestly funded research program whose sponsors have been actively considering participation in multi-national fusion tests in the FFTF. The BR-2 reactor in Mol, Belgium is a 60 megawatt thermal test reactor which supports irradiation tests for CEC and others. This reactor is scheduled for shutdown in 1995.

International Atomic Energy Agency (IAEA)
The IAEA is a world-wide agency which coordinates many facets of nuclear technology evolution among 113 member nations. Many of their current efforts focus on nuclear safety, training, environmental effects, waste problems and safety and environmental problems emerging from Eastern European countries having Soviet designed reactors, but desiring less dependence on the Soviet Union. The IAEA has little funding to directly apply to reactor tests, but coordinates a great deal of testing performed by other nations.

United Kingdom Ministry of Defence
The United Kingdom Ministry of Defence is responsible for nuclear propulsion systems for their Navy. Two United Kingdom test reactors, which supported Navy nuclear programs, were recently shut down leaving a significant and well funded need for irradiation services. The 1958 non-proliferation agreement with the U.S. would need to be checked, but institutional barriers do not appear to be an issue for FFTF use.

Medical Radioisotopes
Sorin Biomedica is a large radiopharmaceutical company owned by Fiat Corporation. It depends on others for its supply of radioisotopes. Across Europe, previous isotope production facilities are old and are gradually reaching the end of plant lifetimes. The result is an apparent future dependence on an essentially single source -- Chalk River of Canada. This situation makes companies like Sorin vulnerable to monopolized supplies.

Market Analysis

Top level officials of the above potential customers were contacted as well as officials from several member nations which have test reactors recently closed or scheduled for closure within the next five years. As expected, near term direct funding from Europe for irradiation test services would be small. However, we universally found sincere interest in future discussions to consider technical collaboration with the FFTF on a "quid pro quo" basis. The capabilities of FFTF were readily recognized by potential European customers to be superior to those in other European test reactors, particularly in its size, degree of instrumentation and neutron flux levels. Collaborative programs with the FFTF were seen as a means of broadening Europe's experience base in plant performance and augmenting irradiation test data being accumulated in Europe. Current attempts at U.S. collaboration with Europe have focused on metal fuel technology . The oxide fueled FFTF, along with potential aqueous processing of nuclear waste at Hanford, is very consistent with Europe's advanced reactor fuel cycle. Each contact expressed interest in collaborative programs for aqueous process, oxide fuel based waste burn technologies. The IAEA Director General in particular expressed enthusiasm in discussing future cooperation with the United States using the FFTF.

The following excerpt from a letter sent to the Marketing Team from the Managing Director of NNL Limited, the principle fast reactor contractor for the United Kingdom, is typical of the reactions we received during our meetings in Europe:

> The information from prototype fast reactors is vital to the substantiation of the economics and lifetime integrity of commercial fast reactor plants. Furthermore, the exchange of information from operating plants and test facilities on an international basis between Europe, U.S. and Japan greatly enhances the quality of the technological database necessary to underwrite the fast reactor system. Such co-operation recognizes that development of the fast reactor is of worldwide concern in meeting the demands for energy throughout the next century. The closure of FFTF will be seen as an indication that the U.S. wishes to opt out of this obligation and as such, will be a setback to the fast reactor cause.

> Although the European focus is on the pool-type oxide fuelled reactor we are, through our exchange agreements, monitoring closely the alternative U.S. approach, i.e., using metal fuel in a small modular reactor. This diversity of approach is, I think, essential bearing in mind the timeframe on which fast reactors may be deployed and theirstrategic role in the future. It is a cause for real concern that available options could be narrowed at a time when nuclear energy is again being recognized as having a significant part to play in dealing with the energy and environmental issues which the world is now facing.
>
> More immediately, the loss of FFTF will weaken the future collaboration between U.S. and Europe on design specific features. I have in mind here testing of components like steam generators, pumps, etc. which may well be of a common design even if the core and fuel differ. The cost of validation of these components will be high and international collaboration involving facilities like FFTF could be the route for confirming their design. Fuel irradiation effects, advanced fuels including nitrides and long term behavior of materials and welds are also important and falls into the same category of common interest. The number of facilities worldwide with these test capabilities is very limited.

The U.K. Ministry of Defence indicated a potential for materials testing, but until further discussions resolve details, the probability of such tests is uncertain. The tests could be valued from $1M - $3M annually.

Sorin Biomedica expressed enthusiastic support for FFTF-produced isotopes and would be a highly interested customer. They would be an unlikely partner in financing near term capital costs at the FFTF. Further discussion of this market is included in the isotope section of this report.

Conclusion

We see no near-term funding for FFTF from Europe, with the exception of isotope production. While near term fusion or navy reactor materials tests are a possibility, further discussion is needed to define these tests and their value would be modest ($1 - $4M annually). As expressed, however, quid pro quo collaboration is quite possible on a test data exchange basis. The value to the United States in such collaborative programs must be assessed by the DOE and State Department as to costs incurred at FFTF versus possible benefits.

FFTF Market Analysis - Japan

Introduction

On May 7-11, 1990 four members of the FFTF marketing team visited key nuclear-related organizations in Japan. In so doing, the team was contacting Japanese interests which have a history of support and involvement with the FFTF, as well as several institutions which, though not having a direct interest in FFTF, share a broader vision of the problem at hand and could offer significant support. The discussions confirmed an absolutely solid commitment by the Japanese to carry on their fifty year nuclear power development program. Advanced reactor research, be it for fission or fusion, is a given. There is no desire to conduct such R&D in a vacuum or isolationist posture. International collaboration is highly desirable, and the United States is their highest priority partner. The Japanese seek long term relationships toward achieving common goals in the nuclear power field and are both willing and capable to carry their fair share of the financial burden. The opportunity exists, therefore, to pursue these goals under conditions that are mutually satisfactory to both countries. Should the United States not choose to accept this partnering opportunity, the Japanese will, as is currently being demonstrated, attempt to establish alternative international agreements such as with the French, and commit additional resources to domestic R&D facilities such as upgrading of their JOYO test reactor. At the conclusion of the visit, the team had just scratched the surface of the medical isotope industry in Japan. Although preliminary at this point, the indication is that Japan imports most of its radiopharmaceuticals and therefore a competitive (to FFTF) domestic production source was not apparent. This investigation continues.

The Potential

The potential Japanese customers for FFTF services are as follows:

Power Reactor and Nuclear Fuel Development Corporation (PNC)
This organization is currently involved in tests using FFTF. There is no question of their desire to continue testing and they stated they have plans to do so. They are highly uncertain of how to proceed, however, given the actions of the United States. They are negotiating with the French for use of the Phenix reactor and have decided to upgrade their Joyo test reactor. With a budget of $1.3 billion and a strong existing relationship, they are a high potential partner. They have requested we work with them in creating a list of long term items for cooperation, including costs and schedule.

Ministry of International Trade and Industry (MITI)
The specific organization within MITI was the Agency of Natural Resources and Energy's Nuclear Power Division. In terms of overall Japanese policy, this is a key organization to influence. They indicated their surprise at the U.S. announcement and yet stood firm on their desire to retain long term relations. They believe it will be more difficult for PNC to continue its future development programs without FFTF. Therefore, they would like to know what other kinds of support they could provide, besides financial, such as fuel and/or components. To proceed further in working to keep FFTF operating, MITI would need a clear signal from DOE that Japanese cooperation is possible and desired.

Japan Atomic Energy Research Institute (JAERI)

Like PNC, JAERI is a user of FFTF services. Stunned by the decision to close the reactor, JAERI reiterated how extremely important their current FFTF tests are, and what a loss it would represent if they could not be finished. They indicated that the DOE offer to move their tests to EBR-II would cost them two to three years with possibly inadequate results. Their next planned program waseven more important, and FFTF was to be the test bed. They most urgently want to develop a long range cooperative agreement for use of the FFTF and offered to work up the specifics for such an agreeement if we would work with them. In their view, FFTF is the only source of neutrons to meet their needs before 2000, when an accelerator may be available.

Mitsubishi Heavy Industries, Ltd. (MHI)

As a component supplier to the nuclear industry, MHI has a private sector interest in advanced reactor development. Of particular interest is the steam generator testing possibilities associated with the FFTF Power Addition. MHI confirmed to the team that the Japanese liquid metal reactor program was moving toward a loop design as its standard, which marries it to FFTF's design. This signals the opportunity for much closer cooperation as highly desirable for the Japanese. MHI agreed to strongly encourage the Japanese government and industry to support continued operation of FFTF.

Tokyo Electric Power Company (TEPCO)

As a utility largely contracting with others for its R&D, TEPCO was not fully briefed on FFTF and its capabilites. However, once Italy explained to them and the relationship it had to their future power generation resources, they expressed interest beyond just materials testing. This was an important utility's perspective in that materials testing was seen as best left to organizations like PNC but that the utilities themselves may have additional needs. They were not specific but said they would consider the opportunity and were willing to receive suggestions from us.

The Japan Atomic Power Company (JAPC)

Intimately knowledgable about FFTF, JAPC has a history of desiring participation in the reactor. This interest is largely driven by the Power Addition and the desire to test steam generators. JAPC has a budget far beyond PNC's, coupled with its need for component testing and reactor operations experience. They will be the operators for Monju, Japan's prototype fast reactor scheduled to operate in 1992. They are very concerned over the FFTF shutdown decision and confirmed Japan's need to commercialize the fast breeder reactor. They still want to participate in the Power Addition and stated that they would discuss with others in Japan ideas for long term use of the FFTF. They asked that we do the same and communicate those ideas to JAPC.

Central Research Institute of the Electric Power Industry (CRIEPI)

This institution once again affirmed the need for advanced reactor development and the breeder in particular. They were not aware of the full extent of capabilities contained in FFTF and were also unaware of some of the important contributions the reactor had made to fuel development. They were interested in U.S. suggestions for long term cooperation to keep FFTF operating, thereby preserving this international asset of future nuclear energy development.

The Kansai Electric Power Co., Inc. (Kansai)

Kansai shared how many organizations in Japan appreciate the value of FFTF and the contributions it has made to Japan's nuclear power development. They offered to urge all in Japan to strongly support continued operation of FFTF. What is needed are concrete proposals for such use and support so that a consensus can be developed in Japan. It will be important to decide what programs go to JOYO and which to FFTF. They concluded by expressing interest in FFTF operating experience for themselves, given their future as an operating utility.

Ministry of Education (MONBUSHO)
Although admittedly confused over the FFTF decision, the researchers that this agency funds have been pleased with the results they have gained from the reactor and continue to want to use it. The agency offered to talk to these researchers about specific new programs and requested we do the same.

Science and Technology Agency (STA)
As an arm of the Prime Minister, the STA is a major player in policy formulation. They stated in no uncertain terms that the closure of FFTF left Japan shocked and confused and will have effects on nuclear development worldwide. The FFTF was a symbol of fast breeder reactor development in Japan. There could be negative effects on existing agreements with PNC and JAERI. The STA and MITI are discussing options for international solutions. The STA believes Japan would be willing to contribute a reasonable share to the continued operation of FFTF. Timing to develop suggestions for funding is critical so that they can be incorporated into STA's budget cycle. This would mean working all summer to have input to the budget by September. They are anxious to hear from the United States regarding this. They are also interested in the results of the European mission. They concluded by apologizing for the absence of the Director General and assured us that he would be briefed on our meeting.

Market Analysis

There is no question that a strong market exists in Japan from a variety of sources for use of the FFTF. This certainty stems from a long history of cooperation and use of the reactor coupled with Japan's commitment to a long term development program and its impeccable reputation for adhering to those commitments. The types of uses for the reactor offer a rich blend of technology that takes full advantage of all of the reactor's capabilities -- materials testing, core-wide testing, component testing, balance of plant, operations and maintenance experience and isotope production. Japan has stated the need for such work to be performed and they have demonstrated willingness to participate given the existing experimental work in progress.

The opportunity exists now to rethink Japan's role in the FFTF and they have agreed to participate in that process. At the heart of this new thinking is the creation of a new kind of partnership beyond the current "customer" relationship. This partnership essentially represents their condition for future cooperation. It is based on a willingness to pay their fair share for the costs of retaining this international asset if, as in any partnership agreement, they have a direct role in the decisions involving the use of their funds. Although such an arrangement is not without other models, it is new to the operation of FFTF.

Conclusion

As has been stated, the decision makers in Japan were confused by the mixed signals being delivered by us on the one hand, and expressed by the DOE in its policy decisions on the other hand. We were treated with great respect and genuine interest with regard to the potential reopening of the case for FFTF.

Our hosts provided us with copies of recent editorials which called for Japan beginning to bear the financial burden of FFTF. In that spirit, they were interested in our estimation of the commitment that would be required of them. We reasoned that a $25M to $30M commitment could cause DOE to reconsider. While they were unprepared to make specific commitments, they were interested in our assessment of what that funding level could buy in terms of experiments. Further, none of our hosts appeared to find the concept unreasonable.

Isotope Production

Introduction

The FFTF team concentrated on the radioisotopes market as the most likely domestic candidate for financial support which had not previously been explored. Irradiation test markets such as the commercial LWR, university research, or other institutional use are known to be quite small.

Use of radioisotopes for medical diagnostic analyses and treatment is expanding at a remarkable rate. Recent market studies suggest growth rates in the 25-50% per year range. The actual rate attained depends on the level of introduction of new therapeutic cancer treatments over the next few years. Commercialization of the new treatment drugs will be limited by approval processes, but will be driven by their efficacy in curing cancer.

This new market growth comes at a time when the U.S. is no longer producing the needed isotopes. All United States requirements for the major isotope of interest, Mo-99, are being met by a single Canadian company which also produces finished medical supplies in direct competition with U.S. suppliers. Absence of a United States isotope supply is a result of the recent demise of the last commercial isotope production reactor for regulatory reasons. The Canadian supplier appears to be working toward worldwide market domination through acquisition of products from European reactors and accelerators and by upgrading domestic resources in Canada.

The current market for the single isotope, Mo-99, is in the $50M - $80M per year range for the raw material. Other radioisotope sales currently range from $9M - $15M annually. Large growth is expected for radiopharmaceuticals over the coming decade as advanced diagnostic and therapeutic procedures, currently under development, become approved by the FDA.

The Potential

Five major radiopharmaceutical concerns were visited. Four were in the United States; one was in Italy. Results are as follows:

E. I. DuPont, Medical Products Department, North Billerica, Massachusetts
DuPont is the largest radiopharmaceutical producer in the United States, having about 50% of the market. They were highly impressed with the ability of FFTF to produce a wider range of isotopes than any other reactor in the United States DuPont subsequently visited FFTF, ATR, and the Omega reactor at LANL, and stated that the FFTF best suited their needs. However, they also made it clear that more than one source of supply is needed to sustain the industry. DuPont confirmed their interest in FFTF by letter stating that they would expect purchase levels in the $5M plus per-year range initially.

Mallinckrodt Medical, Inc., St. Louis, Missouri
Mallinckrodt is a major producer of about 20% market share. They indicated by letter an interest in FFTF as an isotope producer, but did not supply an estimate of anticipated purchase level for FFTF.

Bristol Myers/Squibb, New Brunswick, New Jersey
Bristol Myers/Squibb is a relatively small producer with sales about 10% of DuPont. They verbally expressed interest in FFTF as an isotope supplier. A letter expressing that interest and projected purchases is expected shortly.

Eagle-Picher Research Laboratory, Miami, Oklahoma
Eagle-Picher is a major supplier of a wide variety of isotopes. They are currently seeking a neutron source for production of gamma producing materials. They indicated by letter their interest in initially purchasing $5M to $6M of raw materials from FFTF pending appropriate contractual arrangements.

Sorin Biomedica, Italy
Sorin Biomedica is a major pharmaceutical producer which purchases as much as $20M of raw materials per year. They are concerned about the diminishing number of isotope producers and would welcome an additional supplier.

Japan
Japan is a major importer of medical radioisotopes. While no pharmaceutical companies were visited, Japan appears to be a promising opportunity for FFTF radioisotope sales. The Westinghouse office in Japan researched the Japanese medical isotope market and found it to be worth about 20,400 million yen ($136M) in 1988 and growing about 10% yearly. The principal reactor produced radioisotopes used there are Mo-99 (approximately 5,600,000 curies in 1988), I-131, In-111, I-123, Se-75, and others in smaller quantities.

Market Analysis

The current radioisotope supply and demand situation offers a unique position for FFTF. Within the United States, the Advance Test Reactor and the FFTF appears to be in the best position to produce radioisotopes. The kinds of isotopes needed for today's marketplace can be produced in both reactors, but the emerging therapeutic isotopes can only be produced in FFTF. In addition, the FFTF can be run in a manner optimized for isotope production while the ATR is largely dedicated to Navy and NPR programs, with isotope production as an ancillary effort.

The total initial sales volume for FFTF isotopes is potentially about $21M per year, based on the following breakdown. Since no direct contacts with the Japanese market have yet been made, we are unable to project potential sales.

DuPont	$5M
Mallinckrodt	3M
Bristol Myers/Squibb	1M
Eagle-Picher	5M
Sorin Biomedica	7M
Total:	$21M

For planning purposes we assumed market growth at two levels, 25% per year over a ten-year period, and 25% per year for three years followed by 7% per year. Both cases (Table 5) may be conservative when compared to published market projections and show excellent payback for the investment and excellent return to FFTF for neutron charges. However, the source of the up-front investment costs is not clear. DOE is unlikely to supply the needed funding because of budgetary constraints. Private capital will be needed and estimates are used in the pro forma tables in the financial section of this report,

Conclusion

The market development is dependent upon a significant initial investment to create a production environment. The programs reflect the above figures with the assumption that private funds or a joint venture would make the required investment. The financial analysis calls for a reasonable return on the initial investment and such an arrangement would be possible only with long-term contractural agreements with DOE to ensure operation and stable long term supply. This area deserves continued focus and development.

FFTF Power Addition

In 1986, the City of Richland, together with the Benton and Franklin County Public Utility Districts, proposed a detailed evaluation of creating a utility-owned generation facility at the FFTF using the steam generators developed for the Clinch River Breeder Reactor Project.

This suggestion led to a cooperative agreement between DOE and the three parties, who then called for developing an Advanced Conceptual Design and cost estimate, along with plans for financing, power marketing and other factors, to determine the project's feasibility.

The Potential

The advanced conceptual design was completed in December 1987, and recommends installation of steam generators on two of the three secondary heat transport system loops. The third loop would remain in its present configuration to provide an emergency heat-removal pathway.

Economic and programmatic considerations dictate maximum use of available breeder reactor hardware. Although these units have not been fabricated, the long lead-time materials are available and the design documentation is essentially complete. The net electrical output of the power generating plant is estimated at 110 MW.

The FFTF-Power Addition (FFTF-PA) program has undergone extensive peer review. An external panel of safety experts from the Liquid Metal Reactor community concluded there were no significant issues to prevent safe operation of the FFTF-Power Addition. The panel's report, along with the resolution of identified issues, was presented to the U.S. Nuclear Regulatory Commission for further review. The NRC concluded the proper issues were being addressed and the review process/plan for addressing these issues appeared adequate. Subsequent DOE oversight committee reviews confirmed the safety of the design.

An environmental assessment of the FFTF-PA confirms that the environmental impact is not significant.

Market Analysis

An energy surplus no longer exists in the Pacific Northwest. Both the federal system managed by the Bonneville Power Administration and the region as a whole are in load resource balance. The most recent forecast by BPA indicates there is a 75% chance the region's existing resources will not be adequate to meet load requirements during the 1990s and a 10% chance of deficits over 3,000 MW annual average by 1995.

Forecasts for the California power demand show it growing substantially during the next decade -- with increased purchases of power from the Pacific Northwest. Expansion of the inter-tie capacity to the Pacific Northwest already has been initiated. The calculated cost of power for the FFTF-PA is highly competitive with new generating resources in our area and current prices in California.

Total capital cost of the FFTF-PA is estimated at $195M, including owner's costs, management reserve and escalation. The overall project schedule is 48 months, from the start of detailed design to commercial operation.

The owner's steam payments to DOE are estimated at $8M per year, and are expected to increase at the rate of inflation over the life of the project.

Testing advanced steam generator designs in conjunction with the FFTF-PA generated significant international interest. The FFTF-PA provides the opportunity for long-term endurance testing of large steam generators (150 MW) in a reactor plant environment while generating electricity at the same time. These features exceed those for any conventional liquid metal steam generator test facility in the world.

Conclusion

The City of Richland concluded the project had economic potential, and formally asked DOE to proceed with developing the FFTF-PA project contingent on successful execution of power marketing and financing arrangements. Subsequent discussions with DOE established the content and process for a conditional letter of commitment to allow the city to proceed with the project. However, the letter has not been issued by DOE for a variety of reasons including uncertainty surrounding FFTF's long-term operation.

The project makes sense only as part of a program which supports stable operation of the facility. Its economic premise is promising because it assumes that the cost of operating the facility is also borne by other users. It deserves consideration if a multi-mission approach to its operation is pursued.

Irradiation Services to the U.S. Department of Energy

Introduction

The FFTF was designed as the test reactor to develop fuels and materials and test the components to be used in the Liquid Metal Fast Breeder Reactor being developed by the DOE for commercialization as an electrical power generator. The FFTF has served this primary mission well and earned an international reputation as a world class test facility in the process. The excellent test capabilities have also been recognized and used by several other DOE programs. These DOE needs are ongoing and can be expected to continue and possibly expand for those areas requiring new technology development.

The Potential

In the past, while the support for FFTF operations came from the Advanced Reactor Programs within DOE's Nuclear Energy division, irradiation tests for other DOE programs were accommodated. Programs such as space power and fusion energy found the instrumented, high flux environment of FFTF ideal in which to develop the technology necessary to advance their programs. Even though the DOE's Advanced Reactor Program is declining, other DOE programs and their irradiation testing needs can be expected to remain, some to expand, and new ones emerge. In addition to the existing space power and fusion energy program tests, the Navy is developing an advanced nuclear propulsion reactor and has identified possible material tests in FFTF. The Defense Waste Programs have a stated need for new technologies such as waste burn that can be developed in the FFTF. The production of radioisotopes for non-weapons defense programs has also been identified as a strong potential need for FFTF. It is also believed that there are additional programs and need for products, currently unknown, that will emerge because FFTF's unique capabilities will enable them to happen.

During the transition away from the predominantly Advance Reactor Programs funding base, FFTF irradiation services to other DOE customers can be expected to remain and even expand. Those customers are and will continue to become an important part of the overall FFTF funding strategy.

Market Analysis

Space Power

Space power needs for FFTF irradiation currently span two ongoing space nuclear reactor testing programs (SP-100 and Thermionic Fuel Element) as well as more futuristic programs which are in the conceptual design phase, such as multimegawatt class reactors. The SP-100 program currently has nuclear fuel pin experiments under way in the FFTF and planned through FY 1995. The use of FFTF allows a greater number of longer fuel pins to be irradiated than would be possible in other facilities. An additional SP-100 instrumented materials test is planned for FFTF in FY 1993 (early funding could enhance this schedule). The transfer of this latter test to other facilities will result in a sharp decline of about $2.5M per year in FFTF irradiation services support. Finally, the SP-100 program has planned to perform a seven-year closed loop test in the FFTF which is not possible in any other facility. This test will directly complement the SP-100 nuclear assembly ground test which is not planned to run longer than two years.

The Thermionic Fuel Element program plans an instrumented applied voltage test in the FFTF. This test not only makes use of proven instrumentation and hardware but allows the irradiation of twice as many insulator samples than can be accommodated elsewhere. In addition, the third in a series of instrumented component tests is planned for the FFTF.

Longer term needs for the FFTF have been suggested by both Space Defense Initiative and the Multimegawatt (MMW) programs. If future power sources are liquid metal fast reactors, then MMW irradiation test plans will find the FFTF to be a natural test bed for fuel. If such power sources are gas cooled, then a FFTF gas loop is possible for steady state testing. Various working groups have also indicated the need for instrumented testing for the exotic structural materials which can most certainly be used in future space power reactors.

The level of effort for the space power irradiation testing programs in FFTF is estimated (based on current program budget levels) to be about $5M per year, of which the FFTF irradiation space and neutron charges would be $1.8M per year.

Fusion

After considerable international review, the FFTF has been selected to be the centerpiece of a number of international irradiation fusion component and materials tests. At present, material and component tests are under way for the International Energy Authority, the Government of Japan, as well as the United States fusion program. The importance of these tests is expected to grow over the next few years as fusion energy continues its advance toward commercial power generation. Current planning calls for tests in FFTF to continue beyond 1996, but continued interest in the FFTF by the fusion community is expected well into the next century.

The DOE, through its international agreements, supports a significant portion of the fusion program irradiation tests in the FFTF. Based on the current level of fusion research, the DOE would spend on the order of $1 million per year on FFTF irradiation charges to support their portion of the fusion program.

Navy

Initial scoping tests on new materials for advanced naval nuclear propulsion have been initiated in EBR-II with extensive follow-on testing seriously considered by the Knolls Atomic Power Laboratory for FFTF. If the results of the initial tests are encouraging, a complete FFTF Materials Open Test Assembly (MOTA) will be needed for testing in 1992. Additional Navy MOTA tests extending through the 1990s are likely follow-on needs for this program.

The large test volume and well controlled test conditions of a MOTA are particularly well suited to the needs of the naval program. The testing of full size components is highly desirable and can only be done in the FFTF. The development of design properties of a large number of previously untested fuels and materials will require many specimens and well controlled test conditions.

The advanced naval nuclear propulsion program as currently envisioned by DOE would produce about $2.5M per year of FFTF irradiation services support.

Defense Waste Burn
The FFTF, coupled with improved chemical separation technology, has the potential to help solve issues in the final cleanup of the accumulated defense wastes at Hanford. This "waste burn" technology may offer a less expensive and more environmentally sound approach in dealing with the defense wastes when compared to the reference plan of vitrifying all of the waste and placing it in a deep geological repository. The waste burn approach adds some chemical processing steps to separate and concentrate the long lived transuranic elements in the waste and then uses the FFTF to destroy them by nuclear transmutation to less toxic elements. Successful implementation would allow the bulk of the Hanford defense waste to be stored in subsurface grout vaults as low level waste with the potential savings in glassification and repository charges. The FFTF is the only operating DOE reactor new enough and large enough to support the Hanford waste burn activity. The fair share of the FFTF operating cost for waste burn based on irradiation space and neutron charges is estimated at $20M - $30M per year. About 30 years would be required to complete the task.

An important by-product of defense waste burn in FFTF is production of modest quantities of high quality Pu-238 which is valued at about $2500 - $3000 per gram. Processing costs have been included within the waste burn costs. The Pu-238 is produced by transmutation of americium and neptunium separated from the defense wastes as has been previously demonstrated in FFTF. By-product Pu-238 production would peak at about 7 kilograms annually in the late 1990s and would be worth about $18M per year.

A three year development program to demonstrate the integrated chemical separations technology and FFTF's capability to efficiently perform the transmutations will be performed initially. At the end of that program, it will be decided whether to proceed with the processing and waste burn activities, to perform more development work or to stop work and continue with the reference plan. This development program is estimated to cost between $40M - $50M which includes $10M for FFTF charges in FY 1992 and FY 1993.

This development effort would be aimed strictly at the final disposition of Hanford defense wastes that have their own unique characteristics. There is no attempt to develop any technologies applicable to the proposed Integral Fast Reactor scheme for commercial reactor waste burn being developed at the Argonne National Laboratory.

If this development program successfully demonstrates the desirability of using waste burn technology and FFTF to help dispose of the Hanford defense wastes, then beginning in FY 1994, transmutation of the existing transuranic residues at Hanford would use $10M per year of reactor space and neutron charges. When the fission products and transuranics from the double shell and single shell tanks start to become available in FY 1998, those charges would increase to $20M per year.

Defense Isotopes
Hanford has been approached with increasing frequency as to the feasibility of producing isotopes for non-weapons defense purposes. Post Cold War defense activities are projected to rely increasingly on high-technology isotope applications. A conservative estimate of $3M - $5M annually has been used for FFTF-based on production of relatively low use isotopes such as nickel-63 which is essential to recent

developments accomplished at Sandia Laboratory. FFTF has also been considered for production of large quantities of heat producing thulium-170 which would support tens of millions of dollars in annual reactor charges. Because these programs remain speculative, they are only included in the market plan as "to be determined."

Conclusion

The market analysis shown in the attached (Table 6) pro forma statement of FFTF services to DOE programs could provide on the order of $5M per year, with the Defense Waste Burn program providing another $10M to $20M per year for a total income of $15M per year in the near term and possibly $25M per year at the end of the 1990s. Although FFTF services to the Advanced Reactor programs in support of PRISM and the IFR are likely to continue, this analysis only assumes conclusion of the existing tests and no new follow on programs. We also recognize that new, currently unforeseen DOE needs emerge regularly but that potential has not been included in this analysis.

The waste burn experiments are a key element in developing a multi-mission approach to operating FFTF. The financial projections which are attached provide for a best case scenario. We are convinced that some near-term use of FFTF is important, and certainly long-term use is critical if DOE is to succeed in its efforts in waste management.

We do not believe that enough data currently exists to draw conclusions regarding development of FFTF for waste cleanup activities. We do believe that the potential exists to have FFTF play a significant role in waste management activities. Further we believe the facility lends itself to near-term experiments which would augment programs projected by DOE.

Financial Analysis

Projected potential incomes for operation of FFTF through FY 2000 are presented in Tables 2 - 6. The principal incomes are generated from irradiation services provided to Japan and to DOE programs other than the Advanced Reactor Program and from sale of isotopes. New potential customers discovered during our investigations, not yet contacted, were not included as potential funding sources in this report. Additional development should continue toward large markets such as medical isotope sales to Japan and Europe.

Analysis of some potential markets is incomplete. For instance, little data have been acquired to define the full isotope potential in Europe or Asia.

The Summary Income presented in Table 2 and shown graphically in Figure 1 shows dependence on the Advanced Reactor Program for funding until 1994 or 1995. Total Advanced Reactor Program funding required from 1991 through 1995 would be approximately $170M- $200M which is less than the current reactor projected shut down cost of $250M - $300M over the same period.

IT MUST BE RECOGNIZED THAT THESE CHARTS ARE BASED ON MANY ASSUMPTIONS WHICH HAVE BEEN ALLUDED TO IN THE VARIOUS SECTIONS. THE READER IS CAUTIONED TO USE ANY DATA ONLY IN THE FULL CONTEXT OF THE REPORT AND BEAR IN MIND THE ASSUMPTIONS UPON WHICH THEY ARE BASED.

If we are to achieve an efficient operation of FFTF which is not dependent on long term DOE Nuclear Energy Program funding, we must seek a multi-missioned, integrated approach which takes advantage of the goverment/commercial linkage.

TABLE 2. PRO FORMA INCOME ANALYSIS FOR FFTF

FUNDING SOURCE	(MILLIONS OF 1990 DOLLARS) FY-91	FY-92	FY-93	FY-94	FY-95	FY-96	FY-97	FY-98	FY-99	FY-2000
JAPAN (CASE 2)	1.6	9.6	20.8	26.1	33.4	32.1	28.1	31.0	40.5	36.3
EUROPE	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
MEDICAL ISOTOPES (CASE 1)		14.2	17.7	22.2	27.7	34.7	43.3	54.2	67.7	84.6
DOE IRRADIATION SERVICES (1)	2.9	14.9	14.9	15.4	15.4	15.4	15.4	25.4	25.4	25.4
POWER ADDITION ENERGY SALES					8.0	8.0	8.0	8.0	8.0	8.0
Subtotal:	4.5	38.7	53.4	63.7	84.5	90.2	94.8	118.6	141.6	154.3
ADVANCED REACTOR PROGRAM (2)	79.5	45.3	30.6	20.3	10.0	10.0	10.0	10.0	10.0	10.0
Total Income:	84.0	84.0	84.0	84.0	94.5	100.2	104.8	128.6	151.6	164.3

NOTES:

(1) Excludes support from DOE's Advanced Reactor Program.

(2) Level of Advanced Reactor Program funding needed to maintain FFTF operations through FY-94. After FY-94, a nominal $10 million per year is assumed.

FIGURE 1. PRO FORMA FFTF OPERATIONS INCOME

(Constant 1990 Dollars)

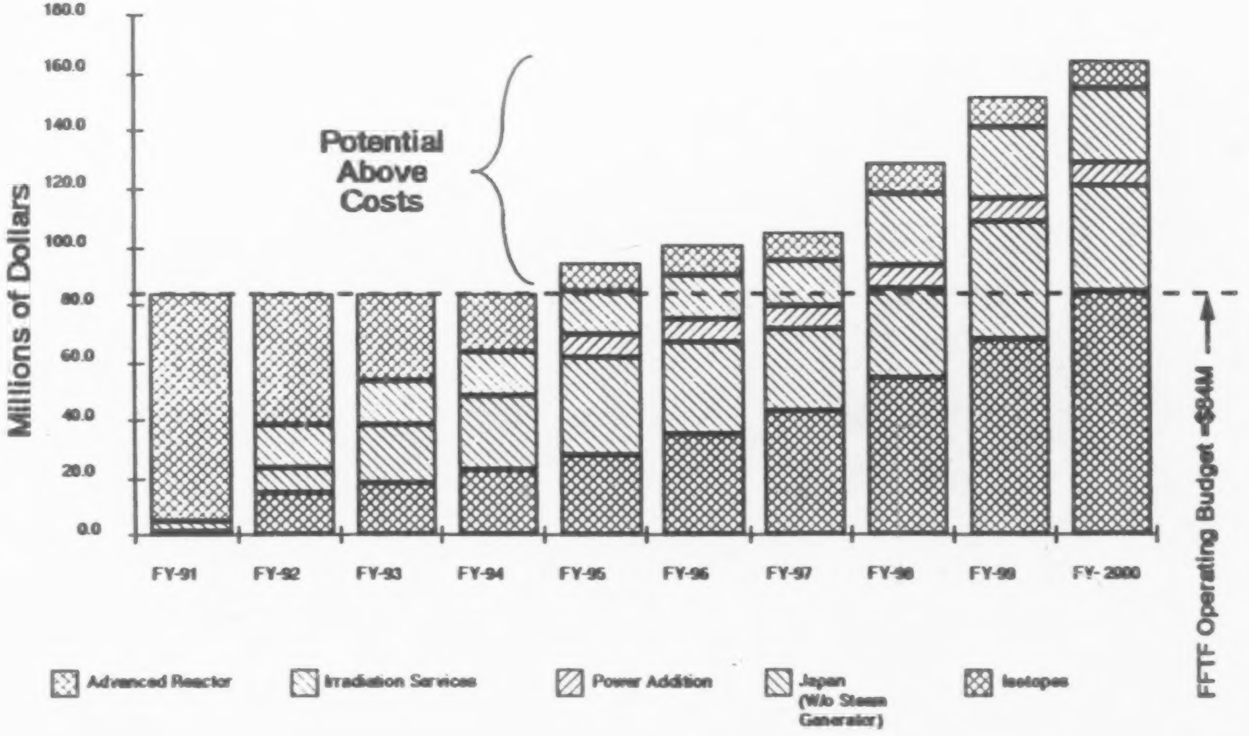


TABLE 3. PRO FORMA FFTF INCOME FROM JAPAN

CASE1.

TOTAL POTENTIAL WORKSCOPE (MILLIONS OF 1990 DOLLARS)

	FY-91	FY-92	FY-93	FY-94	FY-95	FY-96	FY-97	FY-98	FY-99	FY-2000
INSTRUMENTED TESTS										
Fusion MOTA	0.7	0.7	0.7	0.7	0.2					
Fusion Blanket Module					2.4	2.4	2.4	2.4	2.4	2.4
Breeder Materials MOTA		2.3	2.3	2.3	2.3	2.3	0.4			
Low Temp. (Fusion & LWR)			2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
Follow On Fusion MOTA							2.2	2.2	2.2	2.2
Instrumented Fuels Test				0.9	2.1	2.1	2.1	0.5		
Subtotal:	0.7	3.0	5.4	6.3	9.4	9.2	9.5	7.5	7.0	7.0
TESTS IN OPEN CORE POSITIONS										
Phase I Agreement		0.1	1.7	1.7	1.7	1.7	1.7	0.4		
Proposed Phase II Ag'mt			5.2	6.6	9.7	6.5	3.3	2.0	2.0	
Commercial MOX Fuel				2.6	3.3	3.3	3.3	2.0	1.7	0.4
Bundle-Duct Interaction				2.6	3.3	3.3	1.7	0.1	0.8	
Nitride Fuel Development			0.3	3.4	3.3	4.9	4.9	3.3	3.6	3.2
Metal Fuel Development			0.1	2.9	3.3	3.3	3.3	1.7	0.8	
Materials Surveillance		0.1	1.5	1.4	1.4	1.6	1.4	1.4	1.4	1.6
Subtotal:	0.0	0.2	8.8	21.2	26.0	24.6	19.6	10.9	10.3	5.2
CORE WIDE TESTING										
Whole Core Safety Tests	0.5	5.8	5.8	0.4						
Failed Fuel Detection			0.2	0.1	0.1	0.4	10.3	0.3	0.1	0.1
MOX Fuel Core Demonstration							1.0	13.2	22.9	22.9
Core Thermal/Physics Design			0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Subtotal:	0.5	5.8	6.1	0.6	0.2	0.5	11.4	13.6	23.1	23.1
BALANCE OF PLANT										
Center of Excellence	0.4	0.6	0.8	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Plant Component Testing		0.2	0.3	0.4	0.5	0.5	0.5	0.5	0.5	0.5
Sodium Systems Devel.	0.2	0.3	0.4	0.4	0.3	0.2				
System Seismic Testing					0.2	0.5	0.2			
Steam Generator Testing			1.0	1.5	2.5	5.0	6.0	5.0	5.0	5.0
Subtotal:	0.6	1.1	2.5	3.3	4.5	7.2	7.7	6.5	6.5	6.5
TOTAL POTENTIAL INCOME	1.8	10.1	22.8	31.4	40.1	41.5	48.2	38.5	46.9	41.8

TABLE 4. PRO FORMA FFTF INCOME FROM JAPAN

CASE 2.
PROBABLE WORKSCOPE

(MILLIONS OF 1990 DOLLARS)

	FY-91	FY-92	FY-93	FY-94	FY-95	FY-96	FY-97	FY-98	FY-99	FY-2000
INSTRUMENTED TESTS										
Fusion MOTA	0.7	0.7	0.7	0.7	0.2					
Fusion Blanket Module					2.4	2.4	2.4	2.4	2.4	2.4
Breeder Materials MOTA		2.3	2.3	2.3	2.3	2.3	0.4			
Low Temp. (Fusion & LWR)			2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
Follow On Fusion MOTA							2.2	2.2	2.2	2.2
Instrumented Fuels Test				0.9	2.1	2.1	2.1	0.5		
Subtotal:	0.7	3.0	5.4	6.3	9.4	9.2	9.5	7.5	7.0	7.0
TESTS IN OPEN CORE POSITIONS										
Phase I Agreement		0.1	1.7	1.7	1.7	1.7	1.7	0.4		
Proposed Phase II Ag'mt			5.2	6.6	9.7	6.5	3.3	2.0	2.0	
Commercial MOX Fuel				2.6	3.3	3.3	3.3	2.0	1.7	0.4
Bundle-Duct Interaction				2.6	3.3	3.3	1.7	0.1	0.8	
Nitride Fuel Development			0.3	3.4	3.3	4.9	4.9	3.3	3.6	3.2
Materials Surveillance		0.1	1.5	1.4	1.4	1.6	1.4	1.4	1.4	1.6
Subtotal:	0.0	0.2	8.7	18.3	22.7	21.3	16.3	9.2	9.5	5.2
CORE WIDE TESTING										
Whole Core Safety Tests	0.5	5.8	5.8	0.4						
MOX Fuel Core Demonstration							1.0	13.2	22.9	22.9
Core Thermal/Physics Design			0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Subtotal:	0.5	5.8	5.9	0.5	0.1	0.1	1.1	13.3	23.0	23.0
BALANCE OF PLANT										
Center of Excellence	0.4	0.6	0.8	1.0	1.0	1.0	1.0	1.0	1.0	1.0
System Seismic Testing					0.2	0.5	0.2			
Subtotal:	0.4	0.6	0.8	1.0	1.2	1.5	1.2	1.0	1.0	1.0
TOTAL PROBABLE INCOME	1.6	9.6	20.8	26.1	33.4	32.1	28.1	31.0	40.5	36.2

TABLE 5. PRO FORMA MEDICAL ISOTOPE INCOME ANALYSIS FOR FFTF

(MILLIONS OF 1990 DOLLARS)

	FY-91	FY-92	FY-93	FY-94	FY-95	FY-96	FY-97	FY-98	FY-99	FY-2000
CASE 1. (25%/year Market Growth)										
Domestic	0.0	9.5	11.8	14.8	18.5	23.1	28.9	36.1	45.1	56.4
European	0.0	4.7	5.9	7.4	9.2	11.6	14.4	18.1	22.6	28.2
Japan	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
Total:	0.0	14.2	17.7	22.2	27.7	34.7	43.3	54.2	67.7	84.6
CASE 2. (25% Growth/year 1st 3 Years and 7% Thereafter)										
Domestic	0.0	9.5	11.8	14.8	18.5	19.8	21.2	22.7	24.2	25.9
European	0.0	4.7	5.9	7.4	9.2	9.9	10.6	11.3	12.1	13.0
Japan	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
Total:	0.0	14.2	17.7	22.2	27.7	29.7	31.8	34.0	36.3	38.9

TABLE 6. PRO FORMA FFTF INCOME FROM U.S. DEPARTMENT OF ENERGY

(MILLIONS OF 1990 DOLLARS)

IRRADIATION SERVICES	FY-91	FY-92	FY-93	FY-94	FY-95	FY-96	FY-97	FY-98	FY-99	FY-2000
Fusion	0.6	0.6	0.6	1.1	1.1	1.1	1.1	1.1	1.1	1.1
Space Reactor	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
Navy Reactor	0.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Defense Isotopes (1)	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
Defense Waste Burn		10.0	10.0	10.0	10.0	10.0	10.0	20.0	20.0	20.0
Advanced Reactor (2)	TBD	TBD	TBD	TBD	10.0	10.0	10.0	10.0	10.0	10.0
Total:	2.9	14.9	14.9	15.4	25.4	25.4	25.4	35.4	35.4	35.4

NOTES:

(1) Inquiries about production of isotopes for non-weapons defense applications have been received but the size of the market has not yet been determined.

(2) Projected Advanced Reactor program activities in outyears.

Assumptions and Conclusions

The Secretary of Energy, in his January 29 announcement, cited a lack of funding in the diminished DOE Advanced Reactor Development Program and failure to find an alternative DOE mission as the reasons to close FFTF. Our initiative looked beyond the conventional bounds of DOE programs seeking additional commercial and international customers and assessing FFTF as a multi-mission facility.

FFTF is unarguably the newest and finest reactor of its type in the world. All involved would be remiss if operation were suspended without exhaustive efforts to find an alternative. Internal politics, international politics and budget constraints notwithstanding, every avenue must be fully explored to maintain its continued viability.

However, if the various constituencies want FFTF to remain in operation, for nuclear research and development, it must become a multi-mission facility. The team saw a broad range of potentially viable and important missions for this international asset. The transition in mission cannot be expected to be fast or without sacrifice. Both institutional and technical issues must be addressed for effective change to occur. Institutional issues include (but are not limited to) the following:

DOE Commitment to FFTF

Some customers, such as Japan, are confused by mixed signals they have received during the past several months. While our team discussed future solutions to Japans' test needs via FFTF, DOE was negotiating termination of Japanese tests currently within the reactor. The DOE commitment to FFTF operation and it's expanded missions would greatly improve the likelihood of realizing FFTF's non-DOE funding potential.

Ownership

DOE owns the reactor, but has limits on contract flexibility perceived as undesirable by some potential customers. New alternative arrangements may need to be considered, such as privatization to bridge between DOE ownership and non-DOE reactor use.

Management:

Options for management structure should be explored such that non-DOE users have greater authority and voice in assuring long-term viability of their commitments to the reactor. Communications must be improved between DOE and non-DOE users.

Congressional Role

Congress may provide support this year and next year for FFTF operation. However, a multi-year plan that relieves year-to-year fiscal uncertainty should be considered.

Public Involvement:

A plan should be developed to solicit opinion from the local community and region about long term uses. We should be proactive in this regard.

The FFTF's broad capabilities are its greatest asset. During discussions with potential customers, few technical issues were identified. However, some technical issues important to development of the identified potential markets include:

Timely Establishment of Augmented Capabilities
Installation of new features, such as isotope target transport systems within the reactor and an isotope processing laboratory, must be accomplished quickly to begin benefiting from sale of services as outlined in this report.

Environmental Documentation
Early determination of environmental documentation and permit requirements must be initiated to support rapid establishment of new services.

Operational Assurance
Development of plans and actions which will reduce FFTF costs, provide assured fuel supplies, and maintain the plant in a safe, technically current condition throughout its lifetime.

Success in all of the core missions considered in this report requires significant assumptions, for example:

- The DOE will assist in securing supplemental funding sources. This is particularly important to those clients who feel abandoned by DOE's shift in direction regarding FFTF.

- No single mission is capable of fully supporting FFTF. Instead, a combination of missions managed together must be achieved to provide adequate funding and greater stability through diversification.

- Private investment would be found to cover initial startup costs for special commercial missions, such as isotope production.

- Waste burn experiments would be beneficial to DOE waste cleanup and waste management objectives.

- The DOE will continue previously planned experiments requiring FFTF's unique capabilities. Experimenters would include Space Power, Navy, Waste and Fusion Programs. The Advanced Reactor Program was assumed to have no interest beyond the value of currently planned FFTF shutdown costs.

The team recognizes that these assumptions present significant challenges to achieving the projected results. At this early stage the team has not acquired firm commitments for near term funding. However, it has also observed enough expressed need for this facility to recognize its financial viability under the proper charter and structure.

THE TEAM PROPOSES THAT THIS REPORT SERVE AS A JUSTIFICATION FOR MODIFIED CONTINUED OPERATION OF THE REACTOR. CONCURRENTLY, WE CALL FOR THE CONSTITUTION OF A NEW TASK FORCE FOR EXPLORATION OF THE POTENTIAL MARKETS WE HAVE EXPOSED AND THE MAJOR ISSUES WHICH HAVE SURFACED.

> ***Observations concerning any modified operation***
> Continued operation in any form requires sacrifice. We believe there is compromise to be found, through negotiation, between a shutdown budget and modified operation. Such a compromise is a reasonable expenditure considering the potentials uncovered and the inherent value of the facility.
>
> ***Observations concerning a taskforce***
> A newly constitued task force should consist of every constituency of the facility including, but not limited to, DOE Energy Research, DOE Waste Management, DOE Richland, DOE International, State representatives, local representatives and operating contractors. The task force must have negotiated measurable objectives which address the assumptions set forth in this report as well as others found important during negotiations. Funding for the activities for the group should come from the modified operating budget.

Finally it should be noted that the team was under severe time constraints and often beseiged by various interest groups anxious to advance their interpretation of facts and history. In the final analysis Congress will dictate whether money is available and perhaps issue a directive as to how the money will be earmarked. But there is more here than financial issues. Unless and until there is a sincere desire on the part of all concerned, which recognizes that everyone's interests are served by applying creative methods to allowing this facility to play an expanding role in research and development, within the Secretary's policies, little meaningful and lasting progress will be made.

Appendix A

Organization	Location	Contacts	Title
PNC	Tokyo	I. Nakajima	Manager, Policy Division
		K. Shimomura	R & D Planning
		H. Ohishi	Exec. Vice President
		T. Yamagushi	General Manager, Int'l
		K. Onishi	Deputy Dir., Fuel Cycle
		S. Tani	Gen. Manager, Pu Fuel
MITI (Nuclear Power Division)	Tokyo	T Taniguchi	Dir., Nuclear Power Div.
		M Okuda	Deputy Dir. Nuc. Power Div.
		M. Mishiro	Dir., Adv. Reactor Devel.
JAERI	Tokyo	Y. Ihara	President
		T. Fuketa	Vice President
		K. Akama	Director, Int'l Affairs
		T. Kondo	Dir., Fuels & Materials
		M. Iizumi	Director, Planning
MHI	Tokyo	Y. Iida	Chairman
		K. Danno	Vice President
TEPCO	Tokyo	M. Taki	General Manager, Nuc, R&D
		R. Mitsui	Manager, Adv. Power Reactors
		Y. Sagayama	Assistant Researcher
		M. Tabata	Assistant Researcher
JAPC	Tokyo	M. Miura	General Manager, FBR Dev.
		T. Itakura	Managing Director & Exec G.M.
		A. Takeda	Director & Deputy Exec G.M.
		Y. Kurihara	General Manager, Engr Planning
		H. Nakagawa	Exec. Manager, Engr. Dev.
		T. Imai	Manager, Engr. Planning
CRIEPI	Tokyo	S. Hattori	Vice President, Engineering
		F. Maede	
		K. Takahashi	
Kansai Electric Department Power	Osaka	K. Iida	Director & Exec. Vice President
		M. Negishi	Manager, Nuclear Power
		Y. Sumi	Managing Director
		Y. Yamasaki	General Manager
		H. Uda	Manager, Special Assignment

Appendix A (Continued)

Organization	Location	Contacts	Title
Monbusho (Ministry of Education)	Tokyo	J. Yamamoto	Coordinator, Int'l Science Programs
Science & Technology Dev. Agency	Tokyo	Y. Hayashi	Dir., Rsch & Int'l Affairs
		T. Nakahara	Deputy Dir., Power Reactor
		C. Muto	Research & Int'l Affairs
		H. Nakamura	
Sorin Bionedica	Saluggia, Italy	Ezio Graudo	General Manager
		Fabio Lunghi	Radiopharmaceuticals Division Manager
		W. Spagnolo	Director, Research
SCK Nuclear Research Center	Mol, Belgium	Frans Moons	Program Manager, Fusion Technology
		Jean-Marie Baugnet	Program Manager, Nuclear Services (Fisson & BR-2 Reactor)
		Jos Proost	Director, Marketing
Commission of the European Community, CEC	Brussels, Belgium	M. Finzi	Director, Nuclear Fission Program for Europe
NNC Limited	Warrington, England	Derek Taylor	Managing Director
		A. Green	Divisional Manager
		Geoffrey Seed	Proj. Manager, Fast Reactor
		D. Broadley	Chief Engineer, Fast Reactor
Ministry of Defence (UK)	London, England	D.A. McVean	Director, Nuclear Propulsion
UKAEA	Warrington, England	Anthony Judd	Chief Technologist, Fast Reactor Dev. Directorate
CIEMAT	Madrid, Spain	M.T. Callejon	Director of Nuclear Programs
		A.P. Navarro	Director of Fusion for Spain, EUROTOM
IAEA	Vienna, Austria	Hans Blix	Director General
		B. Dircks	Deputy Director General, Adminstration
		Zifferero	Deputy Director General, Nuclear Energy and Safety
U.S. Mission to UN	Vienna, Austria	J.A. Buche	Deputy Representative

Appendix A (Continued)

Organization	Location	Contacts	Title
E.I. DuPont De Nemours & Co. (Inc.)	N. Billerica, MA	R.C. Heiser	Manager, Boston Area Site
Mallinckrodt Medical, Inc.	St. Louis, MO	W.J. Mercer	Vice President & General Manager
Eagle-Picher Specialty Materials Div.	Miami, OK	R.D. Ice	Vice President, Director of Research
Squibb Diagnostics	New Brunswick, NJ	G.F. Thompson	Director, Radiodiagnostic Operations and Productivity

Appendix B

The Secretary of Energy
Washington, DC 20585

February 7, 1991

Her Excellency Akiko Santoh
Minister of State for Science and Technology
The Science and Technology Agency
2-1, Kasumigaseki 2-chome
Chiyoda-ku, Tokyo 100
Japan

Dear Minister Santoh:

I am writing to express my support for the initiative undertaken by Governor Booth Gardner of the State of Washington to find new and expanded uses for the Fast Flux Test Facility. The Department reluctantly concluded early last year that continued operation of the facility was not required in support of United States' nuclear energy programs; however, I strongly believe that the facility has much to offer to the international nuclear community.

The mission of the facility could be directed to support more fully the Japanese nuclear energy program. I believe you will see this as an opportunity of great value because of the recognized capability of the facility for technology development, its demonstrated excellence in operating performance, and the significant contribution it has already made to Japan's advanced reactor development programs.

Governor Gardner has asked the Westinghouse Electric Corporation, which designed, built, and operates the facility under contract with the Department, to assist him in exploring new uses and missions for the facility. A team of representatives from the Westinghouse Electric Corporation and Governor Gardner's staff will be in Japan in February to resume discussions started last spring regarding possible Japanese participation in the operation and use of the Fast Flux Test Facility. Mr. Tom A. Hendrickson, Principal Deputy Assistant Secretary for Nuclear Energy, will join the Governor's team and serve as my representative. I would greatly appreciate your assistance in ensuring that these representatives meet with the appropriate people and organizations in Japan to explore fully this opportunity.

I hope that Governor Gardner's initiative will allow us to continue to work together to support the development of advanced nuclear technologies. I have sent a similar letter to His Excellency Eiichi Nakao, Minister of International Trade and Industry.

Sincerely,

James D. Watkins
James D. Watkins
Admiral, U.S. Navy (Retired)

The Secretary of Energy
Washington, DC 20585

February 7, 1991

His Excellency Eiichi Nakao
Minister of International Trade and Industry
3-1, Kasumigaseki 1-chome
Chiyoda-ku, Tokyo 100
Japan

Dear Minister Nakao:

I am writing to express my support for the initiative undertaken by Governor Booth Gardner of the State of Washington to find new and expanded uses for the Fast Flux Test Facility. The Department reluctantly concluded early last year that continued operation of the facility was not required in support of United States' nuclear energy programs; however, I strongly believe that the facility has much to offer to the international nuclear community.

The mission of the facility could be directed to support more fully the Japanese nuclear energy program. I believe you will see this as an opportunity of great value because of the recognized capability of the facility for technology development, its demonstrated excellence in operating performance, and the significant contribution it has already made to Japan's advanced reactor development programs.

Governor Gardner has asked the Westinghouse Electric Corporation, which designed, built, and operates the facility under contract with the Department, to assist him in exploring new uses and missions for the facility. A team of representatives from the Westinghouse Electric Corporation and Governor Gardner's staff will be in Japan in February to resume discussions started last spring regarding possible Japanese participation in the operation and use of the Fast Flux Test Facility. Mr. Tom A. Hendrickson, Principal Deputy Assistant Secretary for Nuclear Energy, will join the Governor's team and serve as my representative. I would greatly appreciate your assistance in ensuring that these representatives meet with the appropriate people and organizations in Japan to explore fully this opportunity.

I hope that Governor Gardner's initiative will allow us to continue to work together to support the development of advanced nuclear technologies. I have sent a similar letter to Her Excellency Akiko Santoh, Minister of State for Science and Technology.

Sincerely,

James D. Watkins
Admiral, U.S. Navy (Retired)

STATE OF WASHINGTON
OFFICE OF THE GOVERNOR

OLYMPIA
98504-0413

BOOTH GARDNER
GOVERNOR

January 31, 1991

Her Excellency Akiko Santoh
Minister of State for Science and Technology
The Science and Technology Agency
2-1, Kasumigaseki 2-chome
Chiyoda-ku, Tokyo 100
JAPAN

Dear Madame Minister:

Early last year U.S. Secretary of Energy James Watkins announced his intention to close the Fast Flux Test Facility (FFTF) at Hanford, Washington. The Secretary cited the lack of a long-term mission for the facility as the reason for his decision.

In response to this decision, I undertook, with the Secretary's support, an effort to explore the possible expansion of international and commercial uses of the FFTF. I did so because I strongly believe that FFTF has much to offer the international research community and isotope industry.

FFTF is the largest, most modern nuclear test reactor in the world. It has a remarkable history of safe and reliable operations. It is staffed and operated by dedicated and gifted technicians, scientists, and engineers. And, most importantly, FFTF has repeatedly demonstrated its ability to support important research in the fields of nuclear fuels and materials science, as well as advanced reactor design efforts and isotope production.

To assess the level of interest in this unique facility, I sent my personal representatives to meet with representatives of your organization and others in Japan. They also met European nuclear officials and representatives of the U.S. and European isotope industries. My representatives found widespread acclaim and enthusiasm for FFTF. They also found considerable interest, particularly in Japan, in exploring new and expanded uses of the facility.

As a direct result of these findings, Congress has continued to fund FFTF through fiscal year 1991 in hope that new users and funding sources can be found quickly to support continued long-term operations. Secretary Watkins has also agreed to work closely with me to explore potential new uses for FFTF and to actively pursue user agreements with interested parties.

It is for these reasons that Secretary Watkins and I are sending a team to Japan to follow up on the discussions begun last spring regarding potential Japanese participation in FFTF. I believe that such discussions are in the mutual interest of both nations. It is my hope that together we can agree on specific measures which will ensure the long-term success of FFTF as a multi-mission international research facility.

The team will be comprised of Jeff Breckel of my office; Tom Hendrickson, Principal Deputy Assistant Secretary for Nuclear Energy and Secretary Watkins' personal representative; and representatives of the Westinghouse Electric Corporation. I have asked Westinghouse to participate because of its extensive and invaluable knowledge of FFTF and its capabilities.

Your cooperation and support of this initiative will be greatly appreciated. I ask your assistance in ensuring that my representatives have the opportunity to meet with the appropriate representatives of your organization as well as others who may be interested.

Sincerely,

Booth Gardner
Governor

1889

STATE OF WASHINGTON
OFFICE OF THE GOVERNOR

OLYMPIA
98504-0413

BOOTH GARDNER
GOVERNOR

January 31, 1991

His Excellency Eiichi Nakao
Minister of International Trade and Industry
3-1, Kasumigaseki 1-chome
Chiyoda-ku, Tokyo 100
JAPAN

Dear Mr. Minister:

Early last year U.S. Secretary of Energy James Watkins announced his intention to close the Fast Flux Test Facility (FFTF) at Hanford, Washington. The Secretary cited the lack of a long-term mission for the facility as the reason for his decision.

In response to this decision, I undertook, with the Secretary's support, an effort to explore the possible expansion of international and commercial uses of the FFTF. I did so because I strongly believe that FFTF has much to offer the international research community and isotope industry.

FFTF is the largest, most modern nuclear test reactor in the world. It has a remarkable history of safe and reliable operations. It is staffed and operated by dedicated and gifted technicians, scientists, and engineers. And, most importantly, FFTF has repeatedly demonstrated its ability to support important research in the fields of nuclear fuels and materials science, as well as advanced reactor design efforts and isotope production.

To assess the level of interest in this unique facility, I sent my personal representatives to meet with representatives of your organization and others in Japan. They also met European nuclear officials and representatives of the U.S. and European isotope industries. My representatives found widespread acclaim and enthusiasm for FFTF. They also found considerable interest, particularly in Japan, in exploring new and expanded uses of the facility.

As a direct result of these findings, Congress has continued to fund FFTF through fiscal year 1991 in hope that new users and funding sources can be found quickly to support continued long-term operations. Secretary Watkins has also agreed to work closely with me to explore potential new uses for FFTF and to actively pursue user agreements with interested parties.

It is for these reasons that Secretary Watkins and I are sending a team to Japan to follow up on the discussions begun last spring regarding potential Japanese participation in FFTF. I believe that such discussions are in the mutual interest of both nations. It is my hope that together we can agree on specific measures which will ensure the long-term success of FFTF as a multi-mission international research facility.

The team will be comprised of Jeff Breckel of my office; Tom Hendrickson, Principal Deputy Assistant Secretary for Nuclear Energy and Secretary Watkins' personal representative; and representatives of the Westinghouse Electric Corporation. I have asked Westinghouse to participate because of its extensive and invaluable knowledge of FFTF and its capabilities.

Your cooperation and support of this initiative will be greatly appreciated. I ask your assistance in ensuring that my representatives have the opportunity to meet with the appropriate representatives of your organization as well as others who may be interested.

Sincerely,

Booth Gardner
Governor

Congress of the United States
House of Representatives
Washington, DC 20515

February 5, 1991

Her Excellency Akiko Santoh
Minister of State for Science
and Technology
2-1, Kasumigaseki 2-chome
Chiyoda-ku, Tokyo 100
Japan

Dear Madam Minister:

The United States Department of Energy has joined with the governor of the State of Washington and the Westinghouse Electric Corporation in an initiative to sustain long-term utilization of the Fast Flux Test Facility (FFTF) in our state. We are writing to express our support for this effort and to assure you that we are committed to providing the Department of Energy the authority necessary to achieve an international partnership to utilize FFTF in our mutual interest.

Early in 1990, the Department of Energy announced its intention to shut down the FFTF, based on the absence of a definite mission sufficient to justify expenditure of the full operating costs in the current U.S. nuclear energy program. Several subsequent developments have led to the reconsideration of that decision. These include the U.S. Congress' support for FFTF, expressed through funding for operation through September 1991, and the initiative of the Governor of Washington to seek alternative ways to support continued long-term operation.

A U.S. team including senior representatives from the Department of Energy, the governor's office and Westinghouse will visit Japan this month to develop a partnership utilizing FFTF which will support Japan's aggressive energy programs. We want you to know that this effort has our wholehearted endorsement and that we are committed to doing our part to make the effort successful.

Sincerely,

Brock Adams

Brock Adams, U.S.S.

Slade Gorton, U.S.S.

Thomas S. Foley, M.C.

Norm Dicks

Norman D. Dicks, M.C.

Al Swift, M.C.

Rod Chandler

Rod Chandler, M.C.

Jim McDermott

Jim McDermott, M.C.

Sid Morrison

Sid Morrison, M.C.

John Miller

John Miller, M.C.

Jolene Unsoeld

Jolene Unsoeld, M.C.

Congress of the United States
House of Representatives
Washington, DC 20515

February 5, 1991

His Excellency Eiicho Nakao
Minister of International Trade
and Industry
3-1, Kasumigaseki 1-chome
Chiyoda-ku, Tokyo 100
Japan

Dear Mr. Minister:

The United States Department of Energy has joined with the governor of the State of Washington and the Westinghouse Electric Corporation in an initiative to sustain long-term utilization of the Fast Flux Test Facility (FFTF) in our state. We are writing to express our support for this effort and to assure you that we are committed to providing the Department of Energy the authority necessary to achieve an international partnership to utilize FFTF in our mutual interest.

Early in 1990, the Department of Energy announced its intention to shut down the FFTF, based on the absence of a definite mission sufficient to justify expenditure of the full operating costs in the current U.S. nuclear energy program. Several subsequent developments have led to the reconsideration of that decision. These include the U.S. Congress' support for FFTF, expressed through funding for operation through September 1991, and the initiative of the Governor of Washington to seek alternative ways to support continued long-term operation.

A U.S. team including senior representatives from the Department of Energy, the governor's office and Westinghouse will visit Japan this month to develop a partnership utilizing FFTF which will support Japan's aggressive energy programs. We want you to know that this effort has our wholehearted endorsement and that we are committed to doing our part to make the effort successful.

Sincerely,

Brock Adams
Brock Adams, U.S.S.

Slade Gorton
Slade Gorton, U.S.S.

Thomas S. Foley
Thomas S. Foley, M.C.

Norm Dicks
Norman D. Dicks, M.C.

Al Swift, M.C.

Sid Morrison

Sid Morrison, M.C.

Rod Chandler

Rod Chandler, M.C.

John Miller

John Miller, M.C.

Jim McDermott

Jim McDermott, M.C.

Jolene Unsoeld

Jolene Unsoeld, M.C.

FFTF JAPAN TRIP

February 18 - 27, 1991

INDIVIDUALS/ORGANIZATIONS VISITED:

- Ministry of International Trade and Industry
    - Agency of Natural Resources and Energy
- Science and Technology Agency
- Atomic Energy Commission
- Ministry of Education Science and Culture
- Power Reactor and Nuclear Fuel Development Corporation
- Japan Atomic Energy Research Institute
- Ministry of Foreign Affairs

INDIVIDUALS/ORGANIZATIONS (Continued)

- Tokyo Electric Power Company
- Kansai Electric Power Company
- Chuba Electric Power Company
- Japan Atomic Power Company
- Central Research Institute of Electric Power Industry
- Federation of Electric Power Companies
- Japan Atomic Industrial Forum
- Tokyo University -- Department of Nuclear Engineering
- Toshiba Corporation
- Mitsibushi Heavy Industries

INDIVIDUALS/ORGANIZATIONS (Continued)

- Fast Breeder Engineering Company
- Diet Member Yosano
- Former Diet Member Shiina
- U. S. Ambassador Armacost
- American Chamber of Commerce in Japan

Mr. **Morrison**. Thank you both. As you have listed the problems that you have encountered—first of all, the long term relationship that is, I guess, partially a function of the Department of Energy and, certainly, partly a function of the Congress. I think we would appreciate any advice and counsel from you on how we could best approach that. My personal reaction is one of pushing the department to come up with a list of various activities that they would house at FFTF, and this being the justifications for investment. Coordination of various Japanese interests, of course, that's pretty much up to them and also those of you that are actively involved in this directly.

I guess my major question would revolve around the budget cycle. I'm not exactly sure when our committees here will be marking-up, Madam Chairman. One of the points that Mr. Nichols has made in his testimony is that the Japanese budget is six months off of our cycle. Theirs is fairly well set, as I understand it, for 1991. So it would be April of 1992 before the beginning of funding could be available. My presumption is we would need, for appropriation purposes here, some assurance of the Japanese interest and willingness to invest. Is that sort of thing possible by the time we begin mark-ups, I would suppose, in April or May?

Mrs. **Lloyd**. Your point is well taken. I think it's certainly an issue we should bring to the attention of the Appropriations Committee. Although we intend to go to full committee in April, I think we need to also being this matter to the attention of the Energy and Water Appropriations Committee, Mr. Morrison.

Mr. **Nichols**. From the perspective of the team's visit, we made it extremely clear about the urgency of time with respect to issue, that if we lose this window of opportunity this summer, and nothing of substance is seen by the committee or by Congress or OMB, and the decision is to proceed with the shutdown of FFTF, it's essentially then gone. There is very, very little probability of retracting from that decision. So, the Japanese are very, very well versed in our processes over here and understand the necessity of some sort of indication. We are working closely with the various agencies over there and institutions to try to find something that would be a good indication for the committee and for Congress, but that would fit within their process as well.

Mr. **Morrison**. I appreciate your mentioning HR-910, the Commercialization Bill. Madam Chairman, I guess I wanted to mention and make sure it's repeated in the record that the point was made by Mr. Breckel that the introduction of that legislation was significant. If we could process that rather rapidly, it would aid in this process of—very frankly, as I look at it, not just for FFTF, and I would like to build in to the record, just a comment that I think the State of Washington occasionally goes first on some of these things. The Tri-Party Agreement on Defense Waste was, I think, an excellent example of a state working with the Department of Energy and the Environmental Protection Agency.

I think that commercialization of FFTF is also a step ahead by many other areas represented by members on this subcommittee. The public may well have to look at it in future years as some of their facilities are under pressure and they are looking for international support for continued operation.

Mrs. LLOYD. I think it also yields to a broader economic base for our congressional districts and further enhancement of economy. I would like to say that you certainly can anticipate my full cooperation. I would like for the record to show that I will certainly want to be very cooperative in this endeavor.

Mr. MORRISON. Thank you. I appreciate that. I would just like to ask one other question for either one of you. What were the Japanese most interested in, from the point of view of what they would do as a partner in the future operation of the reactor?

Mr. NICHOLS. Really, they had an interest, both near term and long term, because there are several institutions involved in their energy research development and nuclear power development process. Near term interests involve additional tests in FFTF to confirm some of the designs for their Monju reactor fuel and the DFBI, which is the first demonstration fast breeder reactor that they are designing.

They were also very interested in their participation in the international program on fusion reactor materials radiation, which FFTF has been involved in for a number of years, and is considered very important by the Europeans, well as the Japanese and Canadians.

Thirdly, they were very interested in the waste burn or actinide burn or whatever acronym you want to put to it that has become very, very popular in the international community now with respect to the long term issue of handling very high level wastes. The utility people are interested in the operation of FFTF and the observation of a plant of that size and that design as it ages, because it is very, very important to them. They are also very interested in the passive safety testing capability of FFTF that could give them some better insight into the design requirements for a demonstration fast breeder reactor.

Finally, the utilities are very interested in the potential to add a steam generator testing capability to FFTF. As you know now, the heat from FFTF's reactor is dumped to the hot desert air, so it's a very inefficient use of a lot of heat. We have done preliminary designs that show we could add a 300 megawatt thermal steam generator test capability and even add electric power production to that. The commercialization of that and the sale of that would help offset the operation costs, but it's a major capital investment that the Japanese would consider making, because they are very interested in some place to test steam generators. We don't believe they can do that in Japan.

Mr. BRECKEL. I would like to add, too, in the longer term, the Japanese have expressed some interest in radio-isotopes for medical applications. I think they recognize the growing market for those isotopes, both in Japan and abroad. They look to FFTF as perhaps a commercial source of those isotopes. As a commercial source generating revenues, a way to reduce the operating costs and make research programs more economical within the facility itself.

Mr. MORRISON. Thank you. I'm pleased with your efforts and I'd love you to come back with signed contracts. I think this is the next step in what will be an ongoing process. Madam Chairman, thank you for including this panel in this particular portion of our authorization and budget hearings.

Mrs. **Lloyd**. Certainly this panel has contributed to our hearings today. They have enhanced not only our perspective, but new opportunities for growth in our energy market. I will submit my questions in writing in the interest of time, since we have gone over slightly. We look forward to hearing from you again soon.

Mr. **Nichols**. Thank you very much.

Mr. **Breckel**. Thank you.

Mrs. **Lloyd**. I would like to thank the staff and all who worked hard to make this hearing the success that it has been. Certainly, we will have no more important hearings than those we have just concluded. I believe that we will have another hearing next Tuesday—is that correct—on fusion energy. If there are no further comments, the subcommittee stands adjourned.

[Whereupon, at 12:13 p.m., the subcommittee was adjourned to reconvene at the call of the Chair.]

APPENDIX I

Department of Energy
Washington, DC 20585

April 10, 1991

The Honorable Marilyn Lloyd
Chairman
Subcommittee on Energy
Committee on Science, Space, and Technology
U.S. House of Representatives
Washington, DC 20515

Dear Madam Chairman:

On March 29, 1991, I sent you the edited transcript of testimony given on March 6, 1991 by William H. Young, Assistant Secretary for Nuclear Energy.

The information you requested, transcript pages 37, 31, 45 and 53, was still being prepared at the time. The information has been compiled and is enclosed for the record.

If we can be of further assistance to you or your staff, please contact our Congressional Hearing Coordinator, Barbara Campbell, on (202) 586-8238.

Sincerely,

Jacqueline Knox Brown

Jacqueline Knox Brown
Assistant Secretary
Congressional and Intergovernmental
Affairs

Enclosures

Total Levelized Costs for Power Generation
($1989/kWh)

	1990	1995	2000	2005	2010	2015	2020	2025	2030
IPP Hydro	8.2	8.6	8.8	8.8	8.8	8.8	8.9	9.0	9.1
Geothermal	7.2	7.8	7.9	8.1	7.7	7.8	8.3	8.3	8.3
Solar Thermal	20.5	20.7	20.9	15.5	10.0	8.4	7.0	7.2	7.4
Photovoltaics	26.9	21.7	16.5	13.6	10.8	9.4	7.9	7.5	7.0
Wind	10.4	8.7	7.4	7.1	6.7	6.7	7.9	7.9	7.6
Biomass	8.1	8.4	8.7	9.1	9.2	9.3	9.5	9.5	9.5
Advanced Nuclear LWR	8.9	8.9	8.1	7.2	6.4	6.4	6.4	6.4	6.4
2nd Generation Nuclear	10.9	10.9	10.9	9.0	8.0	8.0	8.0	8.0	8.0
Pulverized Coal	6.6	6.8	7.0	7.2	7.4	7.5	7.7	7.8	8.1
AFB Coal	6.8	6.8	6.9	6.7	6.6	6.4	6.0	6.1	6.2
PFB Coal	7.8	7.5	7.3	7.0	6.7	6.6	6.2	5.9	6.0
Gas Combined Cycle	6.2	6.6	7.4	7.7	8.1	8.8	8.8	9.2	9.6

1 Total levelized cost of producing electricity; includes capital, O&M, fuel and finance costs. Costs for some renewable technologies rise in long term due to resource/site limitations.

2 2nd Generation Nuclear has several non-cost advantages over Advanced LWRs.

ROLES OF DOD, DOE and NASA WITH REGARD TO THE SPACE EXPLORATION INITIATIVE

The Space Exploration Initiative (SEI) is a complex, broad-based program that will require the efforts of several agencies. NASA has been designated as the principal implementing agency with the Department of Defense and the Department of Energy having major roles in the areas of technology development and concept definition. To facilitate coordination, the Department of Energy has been made a formal member of the National Space Council in addition to NASA, DOD, and other agencies.

NASA will be the principal implementing agency, and will have a major role in developing key technologies where NASA has the preeminent technical expertise. DOD and DOE will support SEI in developing technologies that are clearly within their development charters, e.g., DOE's charter for nuclear technologies, or where the SEI program can take advantage of DOD or DOE's capabilities or technical expertise. The National Space Council will coordinate the development of an implementation strategy for the SEI by the three agencies.

DOE's role will clearly include the development of space nuclear power and propulsion as an extension of its ongoing program to develop radioisotope and reactor space power systems in support of NASA and DOD for a variety of civilian and defense space missions. DOE can also make important contributions in areas such as nuclear safety and environmental studies; development of supporting technologies in nonnuclear energy sources and in radiation shielding and hardened electronics; assessment of hostile radiation environments and the analysis of health effects and life sciences under radiation conditions; development of high speed computers; and development of resource utilization and manufacturing techniques, and advanced robotic-technologies. As important as these technology thrusts are, DOE is committed to applying its scientific and engineering talents to inspire the Nation's young people in space exploration and in broadening their intellectual horizons.

DOD will have a major role in developing advanced propulsion technology to achieve improved cost, reliability, performance and logistics of existing and future space boosters and transportation systems. DOD also has extensive capability in other space technologies. This common interest of DOD, NASA, and DOE in space technologies, including advanced propulsion, creates an opportunity for cooperative efforts in a variety of areas.

Memoranda of Understanding (MOU) among the agencies will define more explicitly the roles of each agency and their responsibilities with regard to particular technologies. The Department of Energy and NASA have signed a general MOU which supports the following activities: mutual exchange of information; coordination of research and development and concept definition; identification of opportunities for joint programs; development of a process for discussing budget and programmatic planning issues; and coordination of outreach activities.

ROLES OF DOE/NASA/DOD WITH REGARD TO THE SP-100 SPACE REACTOR PROGRAM

The SP-100 space reactor program is sponsored by the Department of Energy (DOE), Department of Defense (DOD), and the National Aeronautics and Space Administration (NASA) through a Memorandum of Agreement (MOA). Funding is provided by DOE, NASA and the Strategic Defense Initiative Organization (SDIO) of DOD as provided in the MOA. The user agencies, NASA and SDIO, are responsible for developing mission requirements for SP-100. Additionally, NASA is responsible for the development of advanced aerospace technologies for the SP-100 power system. The Department of Energy is responsible for the management and execution of the SP-100 space reactor development, demonstration, and qualification project. The SP-100 project consists of the detailed design of a generic flight system, the development and lifetime testing of components, the design and performance testing of major assemblies in a simulated space environment, and the qualification of the power system and components for launch. DOE's funds are directed toward the development and testing of nuclear components and subsystems; subsequent testing in DOE facilities; and system level design activities. SP-100 program activities are coordinated at the senior management level by a Steering Committee consisting of representatives of the three funding agencies and the Air Force.

APPENDIX II

Department of Energy
Washington, DC 20585

April 18, 1991

The Honorable Marilyn Lloyd
Chairman
Subcommittee on Energy
Committee on Science, Space, and Technology
U.S. House of Representatives
Washington, DC 20515

Dear Madam Chairman:

On March 6, 1991, William H. Young, Assistant Secretary for Nuclear Energy, testified before your subcommittee on our Advanced Reactor Programs and Facilities.

Following the hearing, you submitted nine written questions to supplement the record. Enclosed are the answers to those questions.

If we can be of further assistance to you or your staff, please contact our Congressional Hearing Coordinator, Barbara Campbell, on (202) 586-8238.

Sincerely,

Jacqueline Knox Brown
Assistant Secretary
Congressional and Intergovernmental
Affairs

Enclosures

QUESTION FROM CHAIRMAN MARILYN LLOYD

Light Water Reactors

Question 1: How many pressurized water reactors and boiling water reactors are on order throughout the world?

Answer: The term "on order" is not used uniformly throughout the world. However, according to the best available information, as of mid-1990, there were approximately 131 pressurized water reactors either under construction or planned, which includes both firm commitments and planned commitments.

QUESTION FROM CHAIRMAN MARILYN LLOYD

Light Water Reactors

Question 2:	What has been the performance history of pressurized water and boiling water reactors with reference to employee radiation exposure, embrittlement, reliability, and economics, as compared to boiling water reactors?
Answer:	For BWRs, the average 1990 man-rem exposure was 436 man-rem. This was a significant improvement from the 1980 value of 1230 man-rem. For the PWR, the value in 1990 was 294 man-rem. The 1980 value was 597 man-rem. The Electric Power Research Institute goal for future Advanced Light Water Reactors (ALWR) is 100 mrem/yr, applicable to both BWR and PWR types.

The General Electric Advanced Boiling Water Reactor design, that is currently being built in Japan and certified in the United States, is an example of how our advanced designs are minimizing radiation exposure. The elimination of recirculating piping from the dry well area results in a more spacious available area and a much lower radiation exposure of maintenance workers.

Embrittlement of reactor pressure vessels is more of a concern for PWRs than BWRs, due to higher operating pressure of PWRs and smaller core to vessel water gap. The Nuclear

Answer 2 (continued):

Regulatory Commission indicated that a few U.S. PWRs are projected to exceed the current screening criteria before the end of their operating life. For these few plants, remedial actions on the reactor vessels are being taken.

With respect to reliability, the U.S. lifetime nuclear plant capacity factor experience (actual power generation as a percentage of theoretical maximum generation) through 1990 is as follows: PWRs - 67 percent; BWRs - 60 percent; all U.S. reactors - 64 percent.

The average 1985 through 1989 production costs (fuel, operating and maintenance, and capital additions) as computed by the Energy Information Administration for PWRs were 23.2 mills per kilowatt hour and for BWRs were 32.6 mills per kilowatt hour. These are average numbers and there are obviously many nuclear plants and utilities where their experience differs from this average experience.

The ALWR Utility Requirements Document, prepared under the direction of the Electric Power Research Institute, specifies ALWR plant cost objectives that apply to both PWR and BWR designs. For evolutionary (large) plants, the overnight capital cost is 1300 $/KWe. The comparable passive plant value is 1475 $/KWe. The fuel cycle cost for both concepts

Answer 2 (continued): is listed as 9 mills/kwh and operations and maintenance costs are 13 mills/kwh for the evolutionary plant and 16 mills/kwh for the passive plant.

QUESTION FROM CHAIRMAN MARILYN LLOYD

Light Water Reactor

Question 3:	The Department has requested $20 million in FY-92 to begin a new ALWR program for First-Of-A-Kind engineering. Specific funding requirements for future years have not been identified. Before Congress authorizes this request, the Department must provide an explanation of the program. How much funding will be requested in future years, until program completion? How many designs will be selected? What will be the selection criteria? Why should substantial funding be committed to this program before Design Certification is completed for any of the ALWR designs? How much is industry being asked to cost-share? When should funding be provided in relation to a firm utility (customer) commitment to order a new reactor?
Answer:	As background, the Department's current 50 percent/50 percent cost-shared program with the nuclear industry is supporting Nuclear Regulatory Commission (NRC) Design Certification of four Advanced Light Water Reactor (ALWR) plant designs: the large (evolutionary) General Electric Advanced Boiling Water Reactor and Combustion Engineering System 80+ designs, and the simplified passive Westinghouse AP600 and General Electric Simplified Boiling Water Reactor designs. Our target is to receive certification of all four of these designs by 1995. We are working with the NRC, OMB, and the industry in the development of firm schedules for design certification of these designs. The level of design detail needed to achieve Certification will be based on the safety significance of the individual systems, buildings and structures, as determined by NRC.

Answer 3 (continued):

To achieve commercial standardization, a substantial amount of additional "first-of-a-kind" engineering will be needed to substantially complete the plant designs, thereby enabling standardization and providing the confidence in plant cost and construction schedules needed to support plant orders.

The total funding for this program will depend on the number of designs selected and on the amount of cost-sharing. These items will be determined based on responses to the Department's request for proposals. A key ingredient for selections to be made by the Department will be market interest and commitment. By this, we mean the degree to which utilities and other potential U.S. participants provide cost-sharing for the various concepts.

This first-of-a-kind engineering program must be accomplished soon to support the objective of initial operation of new ALWR plants by the turn of the century. Consistent with the progress we plan to make to establish schedules for completing the certifications, we will be initiating the first-of-a-kind engineering in 1992 to enable an initial plant order by 1995. The Nuclear Power Oversight Committee Strategic Plan for Building New Nuclear Power Plants, issued in November 1990, recognizes the importance of the timing of this work to the revitalization of the nuclear industry for the next century.

Answer 3
(continued):

While we will not have orders prior to initiation of the first-of-a-kind engineering program, we will require a demonstration of marketplace interest in the design(s) in this program by substantial U.S. utility cost sharing.

QUESTION FROM CHAIRMAN MARILYN LLOYD

Light Water Reactor

Question 4: The Department's testimony refers to its goal "to commercially standardize the design of at least one Advanced Light Water Reactor (ALWR) by 1995". Since the Department is currently supporting the Design Certification of four ALWR designs, this sounds like DOE may down-select to only one ALWR design for use in the United States. This seems to be contradictory to the original legislation which established the Department and charged it with the statutory mandate to "foster and assure competition among parties engaged in the supply of energy and fuels." Please clarify the Department's position? Is it time to reassess the goal of competitive reactor designs? If so, why? If not, why not? Are there any other federal laws or regulations that restrict anti-competitive activities? Explain why they would not be violated by selection of only one design.

Answer: The Department proposes to support commercial standardization of the ALWR designs as each develops market interest and commitment. Market interest will be determined by the timing and degree of U.S. utilities cost-shared support of a design. We believe that such a program will foster and assure true competition between the competing technologies with the winners being chosen by the market.

There are a large number of Federal laws and regulations prohibiting anti-competitive activities. We fully support competition and will ensure that any selection we make is in full accord with these laws and regulations.

QUESTION FROM CHAIRMAN MARILYN LLOYD

Light Water Reactors

Question 5: The Department is requesting $26M for FY-92 for the AP-600 and SBWR designs. Design Certification is not expected until 1995. The NRC is currently expressing reservations about licensing some of the passive features. Therefore, it seems that the designs may have to be changed substantially during the licensing process. Shouldn't DOE wait to perform First-Of-A-Kind engineering until more is known about the licensing requirements on these designs, so that the work will not have to be re-done? On the other hand, the System 80+ and ABWR designs are very far along in the Design Certification process and it appears that the NRC has not identified the need for any major changes in their designs. Why wouldn't these designs be the first candidates for First-Of-A-Kind engineering funding? What proof of market-acceptance test will be required before government funds are provided for First-Of-A-Kind engineering?

Answer: The Nuclear Regulatory Commission (NRC) standard review plans are based on existing designs utilizing active safety systems. They have stated that in order to review passive designs, some revisions of their requirements will be necessary. Such revisions will rigorously maintain safety margins but allow them to be satisfied by other approaches.

To date, from the substantial design effort that has been undertaken on the passive designs by the reactor manufacturers, architect-engineering firms, utility representatives and the ALWR Utility Steering Committee, the Electric Power Research Institute, the Department, and other industry representatives, there does appear to be any

Answer 5
(continued): outstanding safety issues that will require time-consuming design changes.

Thus, we believe that both evolutionary and passive plants will be ready for commercial standardization, and our policy is to let the marketplace determine the priority to place on their respective support. The market-acceptance criterion that will be required before Government funds are provided for first-of-a-kind engineering (that basically results in commercial standardization) is the degree of commitment, as demonstrated by the amount of cost-sharing that utility or other prospective owners/operators are willing to provide.

QUESTION FROM CHAIRMAN MARILYN LLOYD

Light Water Reactors

Question 6: The Commission's Staff Requirements Memorandum concerning level-of-detail for Design Certification seems to leave the issue in the NRC staff's hands, by approving preparation of a regulatory guide. Since the regulatory guide will not be issued for a year or two, the true level-of-detail required by NRC may not be known until then. Why should the level-of-detail program start before the NRC decision?

Answer: We believe the recent Commission Staff Requirements Memorandum adequately defines the level of detail required for certification. Experience with the first certification program (the Advanced Boiling Water Reactor) has been promising so far. Additional discussion with NRC is continuing on this issue.

QUESTION FROM CHAIRMAN MARILYN LLOYD

Light Water Reactors

Question 7: The Department has stated that it expects the AP-600 and SBWR designs to be submitted to the NRC during FY-92 and to complete Design Certification in FY-95. However, ABB Combustion Engineering, in its testimony, stated that almost seven years will be required for certification of the System 80+ and ABWR designs. It, therefore, seems unrealistic to expect that the AP-600 and SBWR designs can be certified so quickly. Please explain this discrepancy or provide a new schedule.

Answer: There are several factors related to schedules for the certification of the passive plants. First, the regulatory process for certifying all future designs is being established by the evolutionary design certifications. Helping to establish the process was one of the main purposes of this program. As an example, as part of this program, the Nuclear Regulatory Commission (NRC) has firmed up on one of its key requirements regarding the level of design detail to be required for design certification. Development of the passive plant designs and safety reviews is being done with knowledge of these requirements.

Second, the evolutionary plants submitted their applications in modules. NRC has indicated the difficulty in reviewing applications in this manner and has required future

Answer 7 (continued): applicants to submit the entire Standard Safety Analysis Report (SSAR) at the time of application. In addition, the original submittals to NRC on the evolutionary plants did not include the entire balance-of-plant. With the issuance of 10 CFR Part 52, a complete plant scope was required including balance-of-plant systems; the evolutionary plants had to modify their applications accordingly. The System 80+ plant also had difficulty obtaining NRC agreement on their License Review Basis document. These factors contributed delays in the certification of the System 80+. The passive plants will submit a complete application to NRC based on a full scope design.

Third, many of the common issues which a passive plant applicant would have to address if it were "first in line" have been addressed during the review of the evolutionary design. Further, it is DOE's and industry's intent to address most, if not all, critical passive plant issues this year during the passive plant requirements document review, so that NRC could complete its documentation of this review in 1992.

Answer 7
(continued): We are working with NRC, OMB, and the industry in the development of mutually agreed upon schedules for the certification of both evolutionary and passive designs. In these discussions, we will press for ABWR certification by early 1993, four years or less from the completion of the submission of the SSAR.

QUESTION FROM CHAIRMAN MARILYN LLOYD

Light Water Reactor

Question 8: What is DOE's position on this concept of standard reactor designs - namely, a range of programs limited to one 1100MW pressurized water reactor, one 600MW, one modular gas reactor (possibly using the Brayton Cycle), and continuation with the Integral Fast Reactor as a potential principal component in helping to address the nuclear waste problem?

The Department's approach toward standardization of the Advanced Light Water Reactor is to obtain design certification of boiling and pressurized water reactors in both the large and mid-size ranges (1300 MWe and 600 MWe). In addition, we plan to support commercial standardization of these designs as marketplace interest develops.

With regard to the commercial modular high temperature gas reactor (MHTGR), it is being developed on a schedule that builds on the commonality with the MHTGR-NPR that is a candidate reactor design for a New Production Reactor. A licensing plan is being developed to enable certification of a commercial design following operation of one of the NPR modules. Possible development potential and requirements for the direct (Brayton) cycle are also being examined for future applications following the MHTGR steam cycle.

Answer 8 (continued): The Advanced Liquid Metal Reactor (ALMR) has the unique potential to convert fissionable material that would otherwise be disposed of as waste into energy. In addition to the separation of uranium from spent fuel, the pyroprocessing technology under development permits the separation of essentially all of the long-lived actinides which can serve as fuel for the ALMRs, thereby, enhancing resource utilization. With removal of nearly all of the actinides from the waste stream, the volume, mass, and toxicity of waste sent to a geologic repository could be significantly reduced. Continuation of research and development of the reactor and associated fuel cycle technology will provide a sound technical basis for evaluating ALMR technology's possible contribution to the long-term radioactive waste management system by 1995 and could lead to demonstration of the commercial potential of the ALMR system by 2010. In this regard, a National Academy of Sciences study is to be initiated in FY 1991.

QUESTION FROM CHAIRMAN MARILYN LLOYD

Modular High Temperature Gas Reactor (MHTGR)

Question 9: From testimony before the Energy Subcommittee, it appears the Department of Energy (DOE) is faced with mixed objectives. First, there is the design and development of a safer nuclear reactor; and second, there is a need to build a new defense related facility (NPR). While there are common elements of design between the two, the MHTGR program could be abandoned if a heavy water option is selected for the defense reactor. Such a default on the part of DOE's MHTGR program would be a serious blow, since this reactor can be used for a range of services - from electric power generation to water desalinization, to process heat for the industry. In addition, the U.S. has already made a substantial investment in this technology. What commitment can DOE make to rapidly bring this technology to, and through, the demonstration phase? What is the shortest schedule, by milestones, together with associated costs, that DOE can meet? What resources does DOE plan to bring to bear on this effort and when?

Answer: A decision between the heavy water and MHTGR options for the NPR will be made in December 1991. If the MHTGR is not chosen for the NPR, we would evaluate the impact on MHTGR commercialization goals in terms of schedule and total program costs without the commonality advantages offered by the NPR program.

Alternatives other than the early deployment of the MHTGR steam cycle concept would also be evaluated to (1) lower power generation costs, (2) exploit process heat capabilities, (3) continue the gas-turbine HTGR feasibility study, or (4) develop an international project.

Answer 9 (continued): We have developed a plan to bring the MHTGR through the demonstration stage on the shortest schedule possible using the NPR-MHTGR to demonstrate the technology. The NPR-MHTGR is fully funded on an expedited schedule. Major milestones for the NPR-MHTGR would be: completion of final design, 1995; load fuel, 1999; begin full power, four module operation, 2003. Commercial MHTGR plant design certification would be expected about 3 years following the start of full power operation of the NPR-MHTGR.

GENERAL ATOMICS

April 5, 1991

The Honorable Marilyn Lloyd
Chairman, Subcommittee on Energy
House of Representatives
B-374 Rayburn House Office Building
Washington, D.C. 20515

Attention: Cheryl Faunce

Dear Madame Chairman:

It is always a pleasure to participate in our democratic process and I thank you again for the opportunity to testify before the Subcommittee.

Enclosed is a response to the important questions which were provided following my testimony. These questions addressed the MHTGR related activities by NRC and the schedule for completion of the licensing. Basically, I believe NRC has allocated sufficient resources to work with the MHTGR program during 1992 to ensure the completion of a licensing work plan. This work plan will guide the program participants in the preparation of an interim licensing application which will identify, for early resolution, any remaining significant regulatory issues. As always, my optimism on the point requires that NRC maintain the MHTGR review on a high priority.

The licensing/certification schedule for the initial, commercial MHTGR is driven by, and coordinated with, the New Production Reactor program and therefore requires substantial licensing activity in 1992 and 1993 to ensure completion in 2001. Continuing close coordination between these two programs will be possible only if the proposed $25 million budget for FY'92 is available. This coordination will save the country several hundred million dollars for civilian MHTGR development.

Sincerely,

Linden Blue
Vice Chairman

Proposed Answer to Follow-up Question to L. S. Blue's Testimony to Congressional Subcommittee on Energy Research and Development

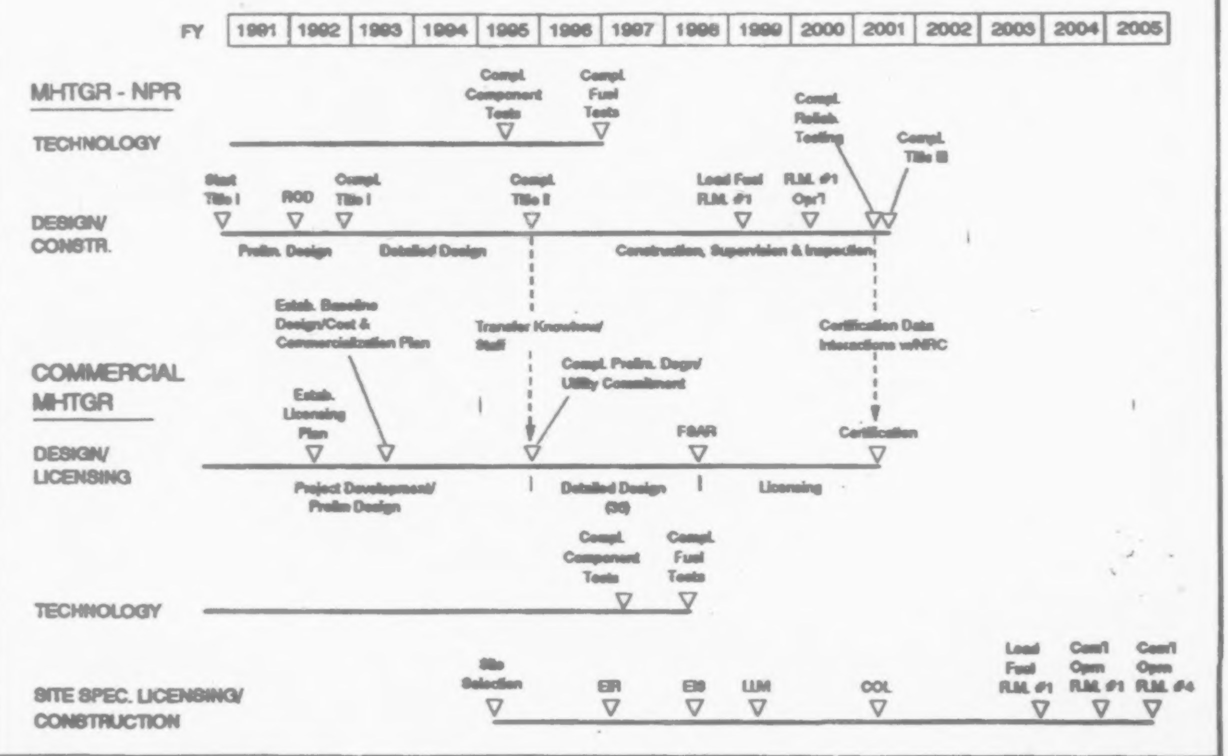
1. Could you give your view on the adequacy and outlook of the on-going GA-USNRC licensing efforts with respect to the Modular High Temperature Gas Reactor? What is your best estimate of a date for completing this effort?

Answer: To maintain coordination and to maximize the benefits of the MHTGR-New Production Reactor, the NRC must work with the DOE and the commercial participants during 1992 to establish a detailed MHTGR licensing plan. During this period, joint efforts are also required to establish the procedures for an interim licensing application aimed to permit identification and resolution of significant regulatory issues.

As I see it, the principal challenge in accomplishing these near-term objectives is to obtain DOE funding for the MHTGR in FY-92 as recommended in my joint vendor testimony. I understand that with recent NRC reassessment of responsibility for advanced reactor review, the NRC appears adequately funded for planned MHTGR activities in 1992. Assuming the NRC places the appropriate priority on the licensing plan, I expect next year to be very productive.

Next year's licensing efforts, however, represent only early steps in the proposed licensing strategy for the commercial MHTGR. For the overall strategy to be effectively implemented, the commercial program must keep pace with the aggressive NPR deployment schedule. This is illustrated in the attached summary level schedule. As shown, we anticipate completion of licensing in the year 2001. At that time design certification based on early NPR operation is scheduled to coincide with the issuance of a combined operating license (COL) for the first commercial plant. To accomplish this we must proceed with the activities scheduled for 1992 to reach NRC concurrence on the resolution of the major licensing issues by 1994. This is required to attract investor support and a utility commitment. Subsequently, the final safety analysis report is scheduled to be submitted in 1998 as the vehicle to obtain the COL.

MHTGR-NPR AND COMMERCIAL MHTGR SCHEDULES


FY
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
MHTGR - NPR
TECHNOLOGY
Compl. Component Tests
Compl. Fuel Tests
DESIGN/ CONSTR.
Start Title I
ROD
Compl. Title I
Compl. Title II
Load Fuel R.M. #1
R.M. #1 Opr'l
Compl. Reliab. Testing
Compl. Title III
Prelim. Design
Detailed Design
Construction, Supervision & Inspection
Estab. Baseline Design/Cost & Commercialization Plan
Transfer Knowhow/ Staff
Certification Data Interactions w/NRC
COMMERCIAL MHTGR
Estab. Licensing Plan
Compl. Prelim. Dsgn/ Utility Commitment
FSAR
Certification
DESIGN/ LICENSING
Project Development/ Prelim Design
Detailed Design (30)
Licensing
TECHNOLOGY
Compl. Component Tests
Compl. Fuel Tests
SITE SPEC. LICENSING/ CONSTRUCTION
Site Selection
EIR
EIS
LUM
COL
Load Fuel R.M. #1
Com'l Opn R.M. #1
Com'l Opn R.M. #4

ARGONNE NATIONAL LABORATORY
9700 South Cass Avenue, Argonne, Illinois 60439 (708)972-4863

April 1, 1991

The Honorable Marilyn Lloyd, Chairman
Subcommittee on Energy
Committee on Science, Space, and Technology
B-374 Rayburn House Office Building
Washington, DC 20515

Attention: Cheryl Faunce

Dear Madam Chairman:

I very much appreciated the opportunity to testify before your Subcommittee on March 6, 1991. I enclose my answer to the follow-up question you sent me in your letter, dated March 26, 1991.

I hope the answer provides you with the information you wish. If I can clarify any points further, I would certainly be pleased to do so.

Sincerely,

C. E. Till
Associate Laboratory Director
Engineering Research

CET:bak
Enclosure

Operated by The University of Chicago for The United States Department of Energy

Follow-up Question
Dr. Charles Till
Argonne National Laboratory

1. **Could you give us your assessment in the overall IFR recycle effort, how the specific problem with regard to technetium is being dealt with and prospects for minimizing the risks associated in connection with fission products which have relatively long half-lives?**

Technetium-99 has a long half-life (2.13×10^5 years) and previous repository risk assessments have shown that Tc-99 dominated the long-term risk. This is because during an assumed leach incident at the repository the models used for risk analysis predict that the technetium can be easily dissolved in ground water and hence escapes the repository.

In the IFR waste treatment process, technetium along with other noble metal fission products will be dispersed and immobilized in a copper metal matrix. The metal alloy is expected to provide better containment for technetium than spent fuel or borosilicate glass because the alloy will provide a more reducing environment and thereby impede the formation of the mobile pertechnetate ion.

Furthermore, the risk of technetium needs to be put in perspective. Technetium-99 emits beta-radiation which is far less carcinogenic than alpha-radiation emitted from actinides, and the total inventory in the spent fuel is in the same range as the Environmental Protection Agency's level of allowable cumulative release from the repository. Put another way, the repository risk assessment studies have shown that the health affects of technetium due to a repository leach incident are about a factor of 20 less than the expected health effects from natural background radiation.

○